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ERRATA

In "*Schwagerina* versus *Pseudoschwagerina* and *Paraschwagerina*," by Carl O. Dunbar and John W. Skinner, *Journal of Paleontology*, vol. 10, no. 2, March, 1936, page 88, Table of measurements of *Schwagerina princeps*, the half diameter of the first volution in specimen 10 should be 0.14 instead of 1.4.

In "Some fusulinid problems," by M. P. White, *Journal of Paleontology*, vol. 10, no. 2, first word in quotes of the second line of the first column, page 130, should read "pores" instead of "spores."

JOURNAL OF PALEONTOLOGY, VOL. 10, NO. 8, PP. 673–683, PLS. 90, 91, DECEMBER, 1936

PENNSYLVANIAN FUSULINIDS FROM OHIO

M. L. THOMPSON

ABSTRACT

Fusulinids have been found at nine horizons in the Pottsville, Allegheny, and Conemaugh series of the Pennsylvanian of eastern Ohio. They represent at least four species (two of which are new) and one new variety of the primitive genus *Fusulinella*, and two new species of *Triticites*. In this paper specimens from eight of these horizons are illustrated and described, and correlations of the containing beds with other fusulinid-bearing horizons are suggested.

The outcrop area of Pennsylvanian strata in Ohio includes practically the entire eastern one-third of the state. Some of the earliest studies of the Pennsylvanian (Coal Measures) rocks of North America were made in Ohio and western Pennsylvania, and the fourfold division applied to the strata of this region (in ascending order, Pottsville, Allegheny, Conemaugh, and Monongahela) has been adopted for the Pennsylvanian of most areas of eastern North America. Also, most subsequent students of the Pennsylvanian of other areas of North America have attempted to correlate the strata they were studying, at least in a general way, with the strata of these four divisions. Although the lithology of the Pennsylvanian rocks of Ohio vary quite rapidly in vertical succession, very thin beds and zones can be recognized over wide areas. Stout (1931) recognizes something over 40 cycles of deposition within the confines of Ohio. He points out that the lower portion of the system contains many marine limestones and shales, but he believes that there are no marine rocks present in the upper portion, that is, from the Skelly limestone of the upper Conemaugh to the top of the Monongahela.

The occurrence of fusulinids in the marine Pennsylvanian strata of Ohio has been known for a long time. In 1846 and again in 1847 de Verneuil (1846, 1847), using for the first time the generic name *Fusulina* in connection with American foraminifers, reported the occurrence of "*Fusulina cylindrica*" in the Vanport limestone and "flint" on Flint Ridge in western Muskingum and eastern Licking counties, Ohio. During the ninety years which have elapsed since de Verneuil's reports, the fusulinids of Ohio have been treated only incidentally. Herrick (1887), Mark (1911), Staff (1912), Condit (1912), Stout (1918), Conrey (1921) and Morningstar (1922) have all mentioned Ohio fusulinids, but neither their generic nor specific identifications are correct according to our present understanding of the fusulinids. Only three specimens of fusulinids have ever been illustrated from Ohio and since these illustrations are external views, they are of relatively little value.

During the summer of 1935 I ob-

tained rather large collections of fusulinids from eight horizons in the Pottsville, Allegheny, and Conemaugh series of Gallia, Perry, and Muskingum counties, southeastern Ohio. These collections contain at least four species and one variety of *Fusulinella* and two species of *Triticites*. *Fusulinella iowensis* Thompson occurs in the lower Mercer and upper Mercer limestones and *F. iowensis* var. *stouti*, n. var., occurs in the Boggs, lower Mercer, and upper Mercer limestones, all of the Pottsville series. I obtained two species of *Fusulinella*, *F. serotina*, n. sp., and *F.* sp., from the Putnam Hill limestone of the Allegheny, and one congeneric species, *F. carmani*, n. sp., from the Vanport limestone of the same series. *Triticites ohioensis*, n. sp., occurs in the Brush Creek and Cambridge limestones of the Conemaugh, and *T. skinneri* occurs in the Ames limestone of the same series.

My detailed study of Pennsylvanian fusulinids mentioned above has yielded certain data in regard to the age relationship between these fusulinid-bearing beds of Ohio and those of the Pennsylvanian of other regions. In contrast to the generally accepted idea that the White Breast coal of the Cherokee of Iowa (= Coal No. 2 of Illinois) is equivalent in age to the base of the Allegheny series, the fusulinids taken by themselves indicate that the Putnam Hill limestone near the base of the Allegheny of Ohio is older than the sixth coal horizon below the White Breast coal in Iowa. The upper portion of the Pottsville, the portion above and including the Boggs limestone, is apparently not greatly different in age from the unnamed limestone which is at least ten coal horizons below the White Breast coal of the Cherokee of Iowa and in which *F. iowensis* occurs, at least the lower portion of the Atoka formation of Oklahoma, the Marble Falls limestone of Texas, and the lowermost portion of the Hartville limestone of Wyoming. Also, the Putnam Hill limestone contains a highly developed representative of the primitive genus *Fusulinella*, which is considerably more advanced than the Pottsville forms and which is slightly more developed and presumably slightly younger stratigraphically than *F. velmae* Thompson of the lower Hartville limestone of Wyoming, as well as *F. llanoensis* Thomas of the Marble Falls limestone of Texas, *F. prolifica* Thompson of the Atoka formation of Oklahoma, and *F. furnishi* Thompson of the lower Minnelusa formation of South Dakota. The only fusulinid known from the Vanport limestone, *F. carmani*, is one of the most highly developed representatives of *Fusulinella* so far described. It is clearly a transitional form between typical *Fusulinella* and typical *Fusulina*, and presumably the beds in which it occurs are slightly older than the sixth coal horizon below the White Breast coal of the Cherokee of Iowa. No true representatives of the genus *Fusulina* were found in my large collection of Ohio fusulinids from and below the Vanport limestone. Representatives of *Fusulina* usually predominate among the fusulinids in

horizons in which this genus is present, and its apparent absence in strata below the Vanport suggests that all of these beds are older than the lowest beds in the Mid-Continent region in which *Fusulina* first appears—though it is possible, but not probable, that the genus *Fusulina* thrived in the Pennsylvanian seas of the Mid-Continent area but at the same time did not migrate as far eastward in these seas as the Ohio region. No fusulinids are available for study from the 200 feet of strata between the Vanport limestone of the Allegheny and the Brush Creek limestone of the Conemaugh. However, Stout (1918, p. 175) lists "*Fusulina*" from the Hamden limestone (which is only about 20 feet above the Vanport limestone) in western Muskingum County, Ohio. He did not describe or illustrate any of his specimens, and he has sent me word that he no longer has them. Part (or all) of these 200 feet of beds are the correlative of the strata in which *Fusulina s. s.* occurs in the Mid-Continent region. The fusulinids of the Brush Creek and Cambridge limestones (Conemaugh) are very closely related to the fusulinids of the Winterset limestone of Iowa, but they are probably slightly more primitive. These limestones are presumably very closely related in age to the Winterset limestone of the lower portion of the Missouri series. *Triticites skinneri*, n. sp., of the Ames limestone (Conemaugh), although small, is rather highly developed for that genus, and the beds in which it occurs are probably lower Virgil in age.

Acknowledgments.—I wish to take this opportunity to express my appreciation to the Graduate College of the State University of Iowa for financial assistance in carrying on the field work necessary for this study, and to Prof. A. K. Miller for his constructive criticism of the manuscript.

SYSTEMATIC DESCRIPTIONS

Genus FUSULINELLA Möller

FUSULINELLA IOWENSIS Thompson

Plate 90, figures 12–16

Girtyina ventricosa MORNINGSTAR, *1922*, Ohio Geol. Survey, 4th ser., Bull. 25, p. 153, pl. 6, fig. 4.

Fusulinella iowensis THOMPSON, *1934*, Iowa Univ. Studies in Nat. Hist., vol. 16, pp. 296, 297, pl. 20, figs. 28–30; *1935*, Jour. Paleontology, vol. 9, p. 293.

Shell small, uniformly fusiform, short, highly inflated. Axis of coiling essentially straight. Poles rather sharply pointed. Mature forms consist of eight to nine volutions and they measure about 2.5 to 2.7 mm. in length and 1.5 to 1.7 mm. in width. The form ratio is about 1:1.5 for the third volution, 1:1.7 for the sixth volution, and 1:1.6 for the eighth volution. The lateral slopes are very steep and they are uniform and convex.

The septa are thick and they are very numerous. The septal count gives 9 to 10 for the first volution, 12 to 14 for the second volution, 18 to 19 for the third volution, 21 for the fourth volution, 26 to 29 for the fifth volution, 31 to 33 for the sixth volution, 32 to 35 for the seventh volution, and 32 to 39 for the eighth volution. The septa are broadly fluted in their lower portions in the extreme polar regions but in the mid-portion of the shell they are essentially unfluted.

The proloculum is spherical in shape and its inside diameter measures about 45 microns. The inner three volutions are somewhat tightly coiled but the rate of

expansion of the shell for the remaining outer volutions is uniform. The average heights of the first seven volutions of a large number of specimens from the upper Mercer limestone measure 25, 35, 39, 55, 73, 94, and 115 microns.

The spirotheca is thick. The upper tectorium is very thick and its lower portion resembles very closely the diaphanotheca below the tectum. The diaphanotheca is very thin in the innermost volutions and its thickness in the third to the ninth volutions measures 3.0, 6.0, 7.0, 8.8, 10.5, 12.3, and 15.8 microns, respectively. The tectoria are poorly developed in the outermost volution.

The tunnel is narrow and high. It is over one-third the height of the chambers and its cross section is elliptical in shape. The tunnel angle averages about 18 degrees in the eighth volution. The chomata are exceedingly well developed in all volutions except the outer half of the outermost volution. They are asymmetrical and extend with decreasing thickness essentially to the poles. Immediately adjacent to the tunnel in the fifth to the eighth volution of specimens of nine volutions the chomata are about three-fourths as high as the chambers.

Remarks.—The above description is based entirely on specimens from the Pottsville of Ohio. As will be noted, the Ohio specimens differ slightly from the Iowa types, but this difference does not seem to me to be of specific or even varietal significance.

This species is so distinct from all other described American species that comparisons seem unnecessary. It is somewhat closely similar and undoubtedly closely related in age to *F. fittsi* of the lower Atoka, however, and to *F. velmae* of the lower Hartville.

Although the stratigraphic ranges of species of *Fusulinella* have not been definitely determined, the information available indicates they are short. It is, therefore, probable that the upper and lower Mercer limestones of the Pottsville are very closely related in age to the unnamed limestone of the lower Cherokee of Iowa from which the types of *F. iowensis* were obtained.

Occurrence.—This species occurs in Ohio very abundantly in the upper Mercer limestone in Blunt Run, about one mile northeast of Stringtown, Muskingum County (pl. 90, fig. 13), and at the cut of Wheeling and Lake Erie railroad, about one-half mile northwest of Rock Cut, Muskingum County (pl. 90, figs. 14, 16). It occurs less abundantly in the lower Mercer limestone in Blunt Run (pl. 90, fig. 15) and in the railroad cut northwest of Rock Cut (pl. 90, fig. 12). The syntypes came from the lower portion of the Cherokee of Iowa.

Hypotypes.—State University of Iowa.

FUSULINELLA IOWENSIS var. STOUTI
Thompson, n. var.

Plate 90, figures 5–11

Fusulina secalica MORNINGSTAR, *1922*, Ohio Geol. Survey, 4th ser., Bull. 25, p. 153, pl. 6, fig. 3.

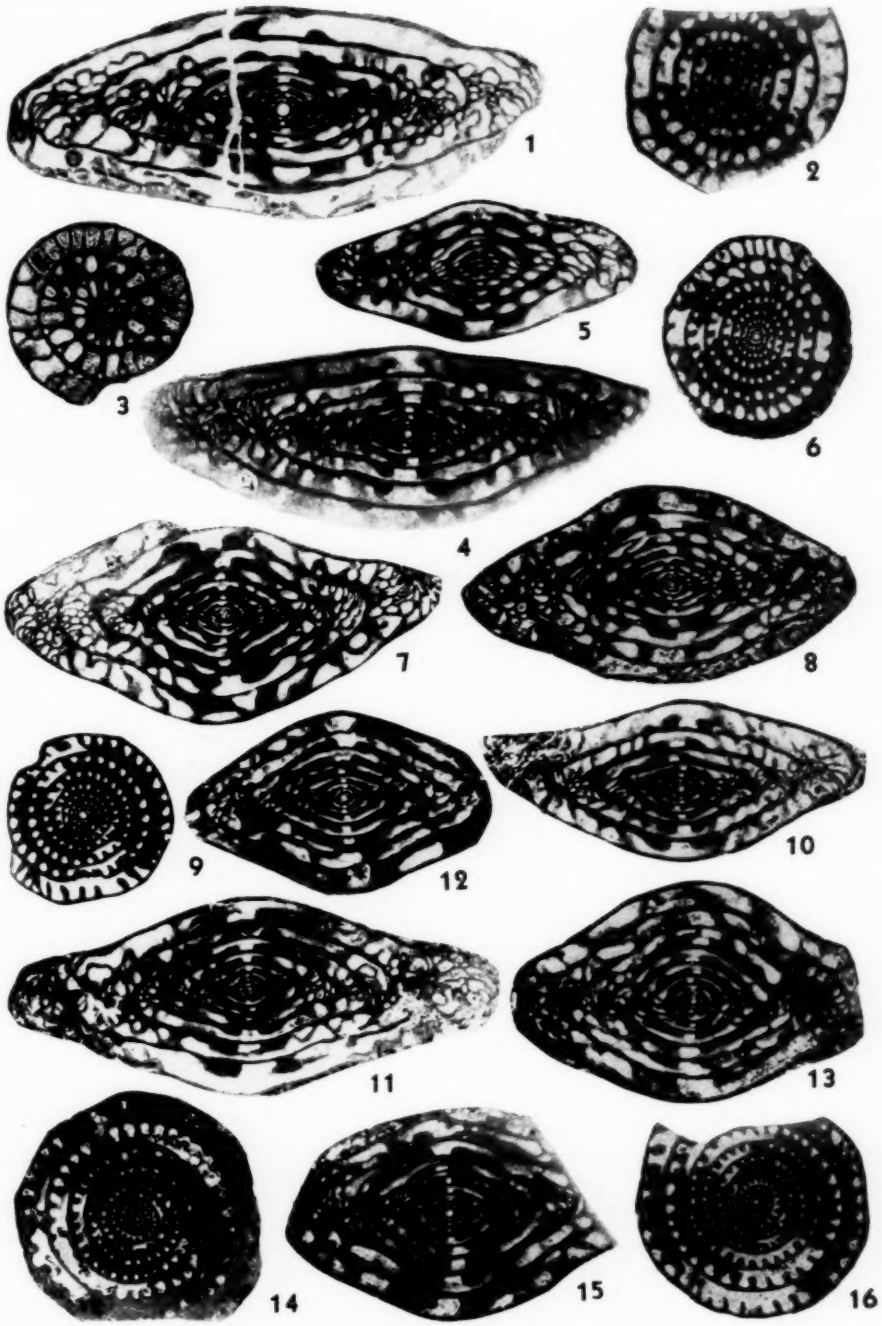
EXPLANATION OF PLATE 90

All illustrations on this plate are unretouched photographs and all of them are magnified ×20.

FIGS. *1–4*—*Fusulinella serotina* Thompson, n. sp. *1, 2*, Axial and sagittal sections, Putnam Hill limestone, Blunt Run, just south of Kelley's Store. *3, 4*, Excentric and axial sections, Putnam Hill limestone, Putnam Hill Park, Zanesville. (p. 677)

5–11—*Fusulinella iowensis* var. *stouti* Thompson, n. var. *5, 8, 9*, Tangential, axial, and sagittal sections, Boggs limestone, Blunt Run. *6*, Sagittal section, lower Mercer limestone, Blunt Run. *7, 10, 11*, Axial sections, lower Mercer limestone, Rock Cut. (p. 676)

12–16—*Fusulinella iowensis* Thompson. *12*, Axial section, lower Mercer limestone, Rock Cut. *13*, Axial section, upper Mercer limestone, Blunt Run. *14, 16*, Sagittal sections, upper Mercer limestone, Rock Cut. *15*, Axial section, lower Mercer limestone, Blunt Run. (p. 675)



Thompson, Pennsylvanian Fusulinids from Ohio

Shell small, fusiform, slightly elongate, central portion inflated. The inner four to five volutions are subrhombic in cross section but in the outer volutions the poles become extended and there the lateral slopes are slightly concave. Mature forms consist of eight to nine volutions. Forms of eight volutions are about 3.3 mm. in length and 1.3 mm. in width. The form ratio is about 1:1.9 for the fourth volution, 1:2.1 for the sixth volution, and 1:2.2 to 1:2.5 for the eighth volution. External furrows shallow.

Septa thick and numerous. The septal count of a typical specimen gives 9 for the first volution, 15 for the second volution, 16 for the third volution, 19 for the fourth volution, 23 for the fifth volution, 27 for the sixth volution, and 31 for the seventh volution. The septa are rather highly fluted in the extreme polar regions but approximately one-half the distance from the pole to the tunnel the septa become essentially straight, and in the mid-portion of the shell the septa are unfluted.

Proloculum spherical. Its inside diameter measures 40 to 45 microns. The rate of expansion of the shell is rather uniform throughout growth, and the average heights of the first seven volutions of a large number of specimens from the lower Mercer limestone measure 26, 37, 50, 67, 87, 113, and 140 microns, and the average heights of the same volutions of a number of specimens from the Boggs limestone measure 26, 35, 48, 56, 74, 95, and 122 microns.

The spirotheca is of moderate thickness. In the innermost volution the diaphanotheca is very thin. It increases in thickness at a rather uniform rate, and in a typical specimen it measures about 8.8 microns in the fifth volution, 10.5 microns in the sixth volution, 14 microns in the seventh volution, and 17.5 microns in the eighth volution.

The tunnel is somewhat narrow. In the eighth volution the tunnel angle measures 19 to 27 degrees, with an average nearer the larger figure. In the inner three to four volutions the chomata are asymmetrical and they extend essentially to the poles, but in the outer volutions they become more nearly symmetrical and do not extend to the poles.

This variety differs from the typical variety principally by its more elongate shell and extended poles, its less well developed chomata, its slightly more strongly fluted septa, and its slightly larger tunnel angle. Also, it apparently has fewer septa than the typical variety.

This form is named in honor of Mr. Wilbur Stout.

Occurrence.—This variety occurs very abundantly in the Boggs limestone in Blunt Run, about one mile east of Stringtown, Muskingum County (pl. 90, figs. 5, 8, 9); in the lower Mercer limestone in Blunt Run (pl. 90, fig. 6) and in the Wheeling and Lake Erie railroad cut about one-half northwest of Rock Cut, Muskingum County (pl. 90, figs. 7, 10, 11); and less abundantly in the upper Mercer limestone in Blunt Run and in the railroad cut northwest of Rock Cut.

Types.—State University of Iowa.

FUSULINELLA SEROTINA Thompson, n. sp.

Plate 90, figures 1–4; Plate 91, figure 9

Fusulina sp. STOUT, *1918*, Ohio Geol. Survey, 4th ser., Bull. 21, pp. 129, 134.
Fusulina secalica CONREY, *1921*, Ohio Geol. Survey, 4th ser., Bull. 24, p. 115.

Shell small, elongate fusiform. Lateral slopes low and uniform. Axis of coiling straight to broadly curving. External furrows shallow but distinct. Mature forms consist of about seven volutions and are about 4.4 mm. in length and 1.4 mm. in width. The form ratio is about 1:1.9 for the third volution, 1:2.7 for the fifth volution, and 1:3.0 for the sixth volution. The innermost volution is subspherical in shape, the next outer two to three volutions are subrhombic in shape, and the remaining outer volutions become elongate.

The spirotheca is of moderate thickness and its structure is typical of the genus. In the inner three to four volu-

tions the tectoria are very well developed but in the outer volutions the tectoria become thinner. The diaphanotheca is extremely thin in the first volution. It increases in thickness very rapidly, and its thickness for the third to the seventh volution measures 7, 8.7, 10.5, 12.3, and 15.8 microns, respectively.

The septa are thin and numerous. The septal count for the first to the seventh volution of the figured sagittal section gives 13, 14, 16, 21, 24, 27, and 31. The posterior and anterior diaphanotheca thin rapidly downward in the septa and in the lower portion of the septa the different layers can not be differentiated. The septa are rather narrowly and highly fluted in the extreme polar regions and the fluting extends with rapidly decreasing height and intensity almost to the tunnel. In the center of the shell the lower portion of the septa are straight to very broadly wavy.

Proloculum spherical. Its inside diameter measures 60 to 100 microns, with an average of about 80 microns. The rate of expansion of the shell is essentially uniform and the average heights of the first seven volutions of a number of specimens from the Putnam Hill limestone near Kelly's store in Muskingum County measure about 35, 44, 60, 80, 115, 140, and 190 microns.

The tunnel is wide and rather low. In the sixth volution it is about one-third as high as the chambers and about five times as wide as high. The tunnel angle measures 33 to 35 degrees in the seventh volution. The chomata are asymmetrical and broad in the inner three to four volutions and they extend laterally from the tunnel to the poles. In the outer three to four volutions the chomata are well developed and narrow, and here they are essentially symmetrical.

Remarks.—This species is clearly a highly developed representative of *Fusulinella*. Its spirotheca has become moderately thin and its septa are more highly fluted than those of most representatives of this genus, and it seems evident that the Putnam Hill limestone is stratigraphically not far below the division between the zone of *Fusulinella* and the zone of *Fusulina*.

F. serotina resembles very closely *F. carmani*, n. sp., to which it is probably ancestral. It may be distinguished from the latter, however, by its shorter and more robust shell, smaller tunnel angle, more tightly coiled shell, better developed chomata, and its less highly fluted septa.

Occurrence.—This species has been found in the Putnam Hill limestone just above Dug Way at Putnam Hill Park in the town of Zanesville, Muskingum County, Ohio (pl. 90, figs. 3, 4), and in the same limestone on the north edge of the NW. ¼ of sec. 20, Muskingum Township, Muskingum County, about one-fourth mile south of the old Kelly's store, just south of the road, in the bed of Blunt Run (pl. 90, figs. 1, 2). Also, specimens are being referred to this species with question from a small exposure of limestone which lies about 80 feet above the lower Mercer limestone, on the west bluff of Blunt Run approximately one mile southeast of the last locality mentioned near Kelly's store (pl. 91, fig. 9).

Types.—State University of Iowa.

FUSULINELLA CARMANI Thompson, n. sp.

Plate 91, figures 10–12

Fusulina cylindrica DE VERNEUIL, *1846*, Am. Jour. Sci. and Arts, 2d ser., vol. 2, p. 293; *1847*, Soc. géol. France, Bull., 2d sér., tome 4, pp. 684, 708.—HERRICK, *1887*, Denison Univ., Sci. Lab., Bull., vol. 2, p. 50, pl. 3, fig. 20.

Fusulina secalica MARK, *1911*, Denison Univ., Sci. Lab., Bull., vol. 16, pp. 278, 286, 287.

Fusulina sp. STOUT, *1918*, Ohio Geol. Survey, 4th ser., vol. 21, pp. 149, 155, 157.

The shells of this species make up the bulk of the thin limestones and "flints" of the Vanport limestone on Flint Ridge in western Muskingum County. Because of its great abundance and its outstanding appearance in the limestone and chert, this form would be noticed by the most casual observer, and it was doubtless

observed by the earliest students of this region. This is undoubtedly the form de Verneuil discussed in his reports of 1846 and 1847, and the species is of more than ordinary interest because it is the first foraminifer in America to which the name *Fusulina* was applied.

Shell small, elongate, irregularly fusiform. Axis of coiling slightly irregular to broadly curving. Poles bluntly to acutely pointed. Lateral slopes low and irregular. The innermost volution is a subellipsoidal in shape but beyond this volution the poles become extended, and the shell becomes subcylindrical in mature individuals. Mature specimens consist of about six volutions and they are about 4.5 to 5 mm. in length and 1.5 mm. in width. The form ratio is about 1:2.2 for the second volution and 1:3.4 for the fourth volution.

The septa are thin and numerous. The septal count for the first to sixth volution is 12 to 13, 15 to 17, 18 to 19, 19 to 21, 22 to 25, and 23 to 28. The septal fluting is more highly developed in this species than in any other known form which I would refer to this genus. The septa are rather highly and narrowly fluted in the extreme polar regions and they are very broadly fluted in their extreme lower portions completely to the tunnel. The different layers of the septa can be differentiated with difficulty in only a few of the sections.

The spirotheca is thin. The tectoria are rather well developed in the inner three to four volutions and in the outer volutions they become very thin. The diaphanotheca increases in thickness from an extremely thin layer in the first volution to about 2.0 microns in the second volution, 6.0 in the third volution, 8.0 in the fourth volution, 10.5 in the fifth volution, and 12.3 in the sixth volution.

Proloculum of medium size. Its inside diameter measures 80 to 100 microns. The average heights of the first six volutions measure about 37, 52, 78, 120, 156, and 190 microns.

The tunnel is wide and low. In the fourth and fifth volutions the tunnel is only about one-third as high as the chambers. The tunnel angle is large and it varies widely among different specimens, and in the fifth volution it measures 40 to 60 degrees. The chomata are well developed. In the inner two volutions they are asymmetrical, but in the remaining outer volutions they become high and essentially symmetrical.

Remarks.—This species is the most highly developed representative of *Fusulinella* with which I am familiar. Its spirotheca is thinner in relation to the size of the shell than most species of this genus, due primarily to thin tectoria. Its septa are more highly fluted than those of most typical forms of this genus. Its chomata are not as highly developed as are those of most *Fusulinella* and they resemble rather closely the chomata of typical *Fusulina*. All of the available evidence indicates that this species is a transitional form between *Fusulinella* and *Fusulina*, and its stratigraphic position is apparently in harmony with this conclusion. Its affinities seem to be closer to the type of *Fusulinella*, however, than to the type of *Fusulina*.

This species resembles in general shape *F. furnishi* and *F. dakotensis* of the Minnelusa formation of South Dakota, but it can be distinguished easily from these forms by its more highly fluted septa, more loosely coiled shell, and its different chomata structure. It is clearly more highly developed than these two species. *F. carmani* is apparently very closely related to *F. serotina* but it has slightly more highly fluted septa, more loosely coiled volutions, fewer volutions, a more elongate shell, and less well developed chomata.

This species is named in honor of Prof. J. E. Carman.

Occurrence.—This species occurs extremely abundantly in the Vanport limestone and flint on Flint Ridge in western Muskingum County, and the types came from about the level of the barn in front of the home of E. R. Drumm, section 15, Hopewell Township.

Types.—State University of Iowa.

FUSULINELLA sp.
Plate 91, figure 8

This form has been found at only one locality in a light-gray limestone which apparently is in the lower portion of the Allegheny and which may be the Putnam Hill limestone. It is known only from one well oriented axial section (pl. 91, fig. 8) and several tangential sections. These specimens clearly represent *Fusulinella* and they apparently represent an undescribed species. Since a description based only on the specimens which I have would be incomplete, however, I hesitate to make them the types of a new species. The following brief description is based primarily on the figured axial section.

Shell small, elongate fusiform, subcylindrical. Axis of coiling essentially straight. Specimen of five and one-half volutions measures 2.8 mm. in length and 0.9 mm. in width. The form ratio is about 1:2.7 for the third volution and 1:3.4 for the fifth volution. Poles sharply pointed. Lateral slopes low and uniform. Axis of coiling essentially straight. The inside diameter of the proloculum measures about 70 microns. The heights of the first six volutions measure about 35, 43, 52, 78, 95, and 120 microns. The spirotheca is thin and its structure is typical of the genus. The septa are broadly fluted in the extreme polar regions but in the mid-portion of the shell they are essentially unfluted. The tunnel is broad and the tunnel angle measures about 53 degrees at the end of the fifth volution. The chomata are well developed throughout the shell except in the latter portion of the last volution. In the inner three volutions the chomata are about one-half the height of the chambers, are asymmetrical and broad, and extend essentially to the poles.

The figured axial section of this form resembles rather closely *F. prolifica* Thompson of the Atoka formation of Oklahoma. However, its chomata are better developed than those of *F. prolifica* and the unfigured tangential sections indicate that there are probably several other distinct differences between these two forms.

Occurrence.—The specimens on which the above discussion is based came from a 2-foot stratum of light-gray limestone on the west side of the highway on the west bluff of Muskingum River, about one mile southwest of Ellis, at an elevation of about 800 feet, 20 feet above the highway, Muskingum Township, Muskingum County, Ohio. This limestone is apparently in the lower portion of the Allegheny series and it may be the Putnam Hill.

Genus TRITICITES Girty

TRITICITES OHIOENSIS Thompson, n. sp.
Plate 91, figures 1–3

Fusulina secalica CONDIT, *1912*, Ohio Geol. Survey, 4th ser., Bull. 17, pp. 44, 88.

Shell large, very long and slender, subcylindrical. In the inner four to five volutions the poles are sharply pointed but in the outer volutions the poles are bluntly pointed. Mature individuals con-

EXPLANATION OF PLATE 91

All illustrations on this plate are unretouched photographs.

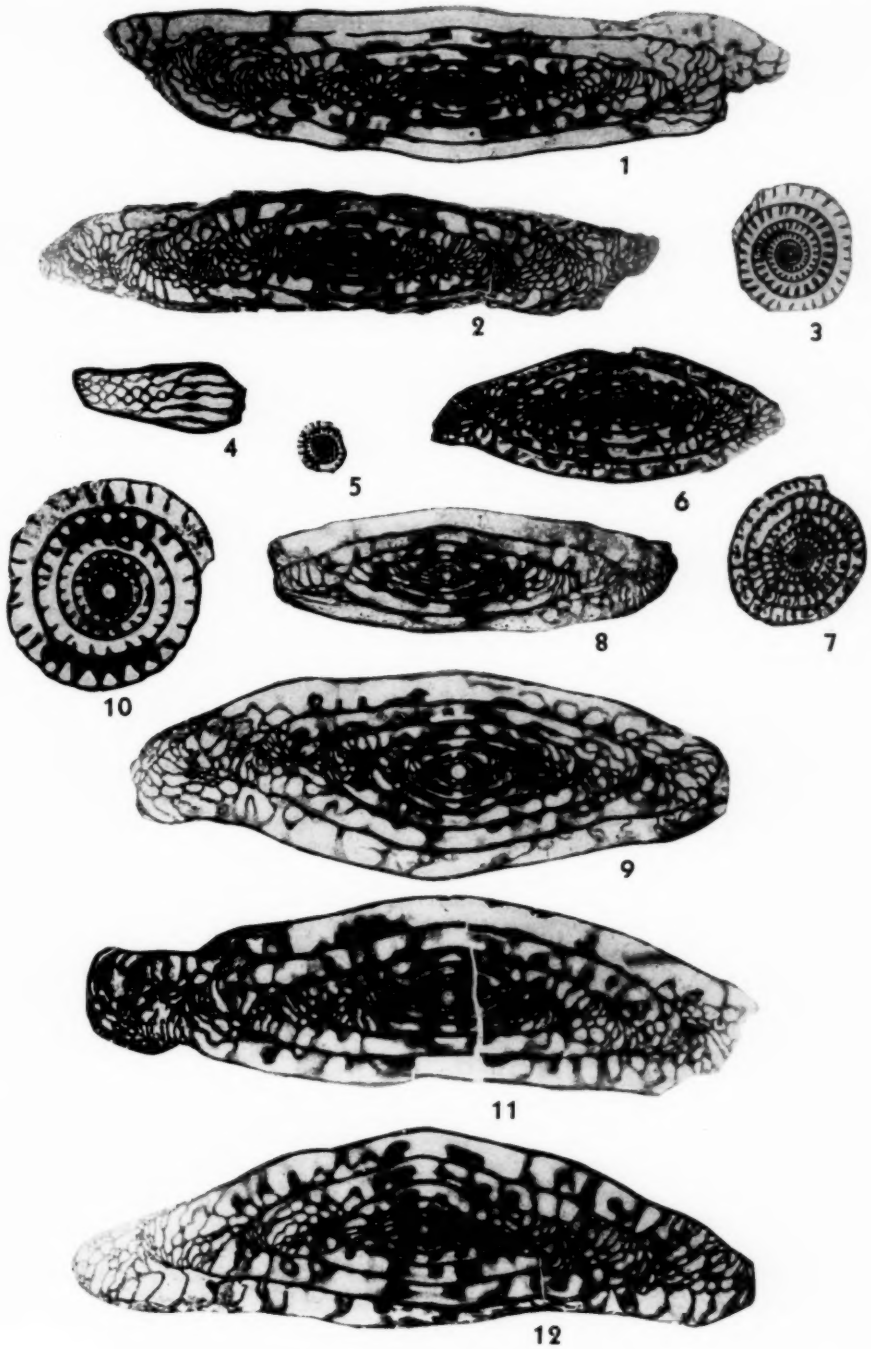
FIGS. *1–3—Triticites ohioensis* Thompson, n. sp. *1, 2*, Axial sections, Cambridge limestone, ×10. *3*, Sagittal section, Cambridge limestone, ×10. (p. 680)

4–7—Triticites skinneri Thompson, n. sp. Ames limestone. *1*, Oblique tangential section, ×10. *5, 7*, Sagittal sections of young and mature individuals, ×10; *6*, axial section, ×10. (p. 682)

8—Fusulinella sp. Axial section, ×20. (p. 680)

9—Fusulinella serotina Thompson (?), n. sp. Axial section, Putnam Hill limestone?, ×20. (p. 677)

10–12—Fusulinella carmani Thompson, n. sp. *10*, Sagittal section, ×20. *11, 12*, Axial sections, ×20. (p. 678)



Thompson, Pennsylvanian Fusulinids from Ohio

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sist of about eight volutions and they measure about 9 mm. in length and 2 mm. in width. The form ratio is about 1:2.3 for the third volution, 1:3.0 to 1:3.4 for the fifth volution, and 1:4.0 to 1:4.5 for mature specimens.

The septa are thick and numerous. They are composed of the downward deflection of the tectum of the spirotheca and a lighter thicker layer on the posterior side. This lighter layer wedges in between the tectum of the septa and the keriotheca of the spirotheca, and it is apparently structureless. The keriotheca extends a short distance down the anterior side of the tectum. Near the tunnel in all volutions except the outer one or two the septa are coated by thick deposits of dense calcite which do not extend onto the lower surface of the spirotheca. These dense deposits are apparently continuous with the chomata. The septal count for the first seven volutions is 11, 14 to 16, 18, 21 to 23, 26, 28 to 33, and 30 to 34. The septa are narrowly and highly fluted in the polar regions and in the outer four to five volutions the lowermost portion of the septa are very broadly fluted almost to the tunnel.

The proloculum is small and its inside diameter measures 45 to 85 microns, with an average of about 60 microns. The inner three volutions are rather tightly coiled, and at the end of the third volution the rate of expansion of the shell increases very rapidly. The heights of the first seven volutions measure 26, 43, 52, 104, 156, 234, and 260 microns, respectively.

The spirotheca is thin for this genus, but it is clearly composed of a tectum and a keriotheca. The alveoli are easily distinguished only in the outer four volutions. The spirotheca measures 5, 9, 12, 21, 26, 44, and 53 microns in the first seven volutions.

The tunnel is wide and the tunnel angle measures 42 to 60 degrees in the sixth and seventh volutions, with an average of about 53 degrees. The chomata are well developed and in the fifth volution they are slightly asymmetrical and are almost one-half the height of the chamber. In the outer volution the chomata are very feebly developed.

Remarks.—This species belongs to the group of forms which are generally included in *Triticites irregularis* Staff, as emended and restricted by Dunbar and Condra (1927). In Staff's (1912) original description he referred at least four species, representing two genera, to *Fusulina centralis irregularis*. It seems evident that figure 9 on his Plate 16 and figures 5 and 11 on his Plate 17 are referable to the genus *Fusulina s. s.* and these specimens are almost certainly of Des Moines age. Dunbar and Condra (1927) have pointed out that Staff's description apparently was based on forms like figure 10 on his Plate 17 and they have restricted the species to this type of form. As these authors suggested, our concept of *T. irregularis* should be based on the specimen illustrated by Staff as figure 10 on his Plate 17, and I am here designating it as the holotype of that species. Staff neither gave dimensions of this holotype nor did he give the magnification of his illustration of it; therefore, it is not possible to understand clearly the exact nature of this species without a restudy of the holotype. The holotype came from Kansas, but the horizon and locality in Kansas were not given by Staff. In general shape of shell, development of volutions, tunnel angle, and septal fluting the holotype resembles very closely forms which are abundant in the Winterset limestone at Winterset, Iowa; and Newell (1934) has pointed out that the fusulinid species found in the Winterset limestone is now generally accepted as being typical of *T. irregularis*. A part of Staff's original syntypes of this species came from Iowa, and it is entirely possible that they came from the old quarry in the Winterset limestone at Winterset.

Dunbar and Condra allowed *Triticites irregularis* more latitude than seems advisable at the present time, and it now

seems to me that this group includes several distinct forms which are closely similar in general shape and stages of development. Dunbar and Condra recognized, however, certain differences among their specimens which range in age from the Brownwood shale (Canyon) of Texas to the Deer Creek limestone (Virgil) of Nebraska. White (1932) has recently described and illustrated a number of forms from the Mineral Wells formation (Strawn), Palo Pinto formation (Canyon), and Graford formation (Canyon) of Texas as *T. irregularis*. He recognized four forms among his collections and designated them as "First Form," "Second Form," "Third Form," and "Fourth Form." Through the courtesy of Mrs. Helen Jeanne Plummer and Mr. John W. Skinner, I have been able to study topotype material of part of White's "forms" and, although I have not studied material from all of White's horizons, it seems to me that he included several distinct species in *T. irregularis*. Some of these forms described by White are clearly among the earliest and most primitive representatives of the genus *Triticites* known.

From a direct comparison of representatives of the form from the Winterset limestone at Winterset, Iowa, and the published illustration of the holotype of *T. irregularis* with the Ohio form described above as *T. ohioensis*, several distinct differences become apparent. The Ohio specimens are more nearly uniform in shape and their lateral slopes are typically lower and more nearly uniform throughout the length of the shell. Although a few of the Ohio specimens are slightly inflated in their central portion, the central inflation of the Iowa specimens and the holotype of *T. irregularis* is more pronounced, and their lateral slopes and axis of coiling are more irregular. Also, the spirotheca of the Iowa form is slightly thicker, the alveoli are slightly coarser, and the average for the tunnel angle is smaller than in the Ohio form. None of these differences are outstanding but taken together they constitute ample justification for the separation of these two forms into two distinct species.

Triticites osagensis Newell and *T. neglectus* Newell from the Missouri series of Kansas and Oklahoma, respectively, resemble *T. ohioensis* in general shape and size, but their well-developed septal fluting, as well as several other internal characters, definitely distinguish them from the Ohio form.

Occurrence.—This species occurs in the Brush Creek and Cambridge limestones (Conemaugh) near the top of the west bluff of Raccoon Creek, 3 to 4 miles north of Salome Church, section 2, Perry Township, Gallia County, Ohio.

Types.—State University of Iowa.

TRITICITES SKINNERI Thompson, n. sp.

Plate 91, figures 4–7

Fusulina secalica CONDIT, *1912*, Ohio Geol. Survey, 4th ser., Bull. 17, pp. 29, 287.

Shell small, short, uniformly fusiform. Poles acutely pointed. The innermost two volutions of this species are subspherical in shape, but the next outer three to four volutions become elongate and in the outer two to three volutions the chambers become more highly inflated. Mature specimens of nine volutions measure about 4.8 mm. in length and 1.9 mm. in width. The form ratio is about 1:2.4 for the third and fifth volutions and 1:2.0 for the seventh volution. Axis of coiling essentially straight. Lateral slopes rather steep and uniform.

The septa are thin and are numerous. The septal count for the first eight volutions is 9, 14, 16, 18, 24, 27, 32, and 35. The septa consist of a tectum and a thick lighter layer on the posterior side which is apparently structureless. The septa are narrowly and highly fluted in the polar regions, and the lower portions of the septa of the outer volutions are very broadly fluted completely across the mid-portion of the shell. The septa of the inner five volutions are fluted only in the extreme polar regions.

The spirotheca is composed of a tectum and a keriotheca with rather coarse alveoli. The spirotheca measures 3, 5, 10, 13, 17, 26, 53, 70, and 60 microns in the first nine volutions.

The proloculum is very small for the genus and its inside diameter measures 35 to 40 microns. The shell of this species is tightly coiled and the heights of the first nine volutions measure about 17, 22, 26, 43, 87, 150, 174, 234, and 260 microns.

The tunnel is low and wide. In the ninth volution it is about one-fourth as high as the chambers and about one-eighth as high as wide. The tunnel angle measures about 30 degrees in the ninth volution. In the inner six volutions the chomata are well developed and they extend about one-half the distance to the poles. In the outer volutions the chomata are asymmetrical and of moderate width, and there they are over one-half the height of the chambers.

Remarks.—There is close resemblance in general shape and size between *Triticities skinneri* and *T. moorei* Dunbar and Condra. Thin sections of the syntypes of *T. moorei* have never been published as far as I have been able to determine. However, a comparison of the syntypes of *T. skinneri* with Dunbar and Condra's description of the syntypes of *T. moorei*, White's description and illustrations of topotypes, and thin sections of topotype material kindly sent to me by Mr. John W. Skinner shows that the internal characters of these two forms are quite different. *T. moorei* has a larger proloculum, thicker spirotheca for corresponding volutions, fewer volutions at maturity, and a larger tunnel angle than *T. skinneri*.

This species is named in honor of Mr. John W. Skinner.

Occurrence.—The syntypes of this species came from the Ames limestone, immediately over the old abandoned tunnel of the Wabash railroad, about one mile west of Portersville, Perry County, Ohio.

Type.—State University of Iowa.

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M. L. THOMPSON, STATE UNIVERSITY OF IOWA, IOWA CITY. PRESENT ADDRESS, SCHLUMBERGER WELL SURVEYING CORPORATION, HOUSTON, TEXAS. MANUSCRIPT RECEIVED BY THE EDITOR, JANUARY, 11, 1936.

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A NEW PERMIAN AMMONOID FAUNA FROM WESTERN AUSTRALIA

A. K. MILLER

ABSTRACT

In this paper are described and illustrated two new species of ammonoids, *Thalassoceras wadei* and *Metalegoceras clarkei*, from the "Lower Ferruginous series" of the Kimberley Division. It is concluded that the beds from which these cephalopods came are Middle Permian in age and are to be correlated in a general way with the *Metalegoceras jacksoni* beds of the Irwin River Coalfield (Western Australia), the Bitauni beds of Timor, the Artinsk sandstone of the Urals, and the Leonard formation of western Texas.

Recently Professor E. de C. Clarke of the University of Western Australia sent me for study six small collections of ammonoids and bellerophontids which were obtained by Dr. Arthur Wade "from beds of younger than Devonian age in the Kimberley Division" of Western Australia. These came from the following localities: 3 miles east of Nura Nura; west of Jimberlurah Tank; south of Fishery Hill, Nooncanbah; 9½ miles west of Nooncanbah; northeast of Ibis Hill; and Skeleton Hill (Wade, 1924). Unfortunately, only the specimens from near Nura Nura reveal sutures and are identifiable. I have listed the other localities largely in the hope that I might thereby stimulate future workers in this region to visit these places and try to obtain more and better-preserved material. Due to the admitted superiority of ammonoids for detailed correlation of Late Paleozoic strata, the importance of the discovery of these goniatites at various localities and perhaps several horizons in the Kimberley Division (more or less intermediate in position between Timor and the Irwin River Coalfield) can hardly be overemphasized, and I want to take advantage of this opportunity to express my sincere thanks to both Professor Clarke and Doctor Wade for entrusting me with the study of these valuable specimens.

The collection from near Nura Nura contains only four ammonoids, but all of them retain their sutures. They represent two species which I am describing below as *Thalassoceras wadei* and *Metalegoceras clarkei*. Professor Clarke has written me that the beds from which these specimens came

> have been regarded as of probably Lower Permian age, although there was no definite evidence on this point from the fossils. Associated fossils are several species of lamellibranchs, crinoids known only as stem plates, and Bryozoa, the last as yet unidentified. They are from the "Lower Ferruginous" series, the "Upper Ferruginous" containing fossils of definitely Permian age.

To this it should be added for the sake of completeness that the collection I am studying contains, in addition to the cephalopods, four rather small poorly-preserved bellerophontids.

In so far as is now known, both

of the ammonoid genera represented are confined to the Permian. *Thalassoceras* (exclusive of *Prothalassoceras*) is known to occur in the Sosio beds of Sicily, the Artinsk sandstone of the Urals, and possibly the Trogkofel limestone of the Carnic Alps. All of these beds are Middle Permian in age. *Metalegoceras* (of which *Asianites*, *Eothinites*, and *Dodecalegoceras* are synonyms) has been found in the Permian beds of the Irwin River Coalfield (Western Australia), the Somohole and Bitauni beds of Timor and Letti, and the Artinsk sandstone of the Urals. The Somohole beds are generally regarded as Lower Permian, but the rest of the beds listed are of Middle Permian age. Furthermore, the representative of *Thalassoceras* under consideration, *T. wadei*, is closely similar and, therefore, presumably closely related to *T. chabakowi* Voinova of the Artinsk sandstone, and *M. clarkei* finds a close analogue in *M. australe* (Smith) of the Bitauni beds. All of these facts point to the conclusions that the Western Australia beds ("Lower Ferruginous series") which yielded the specimens I am studying are Middle Permian in age and are to be correlated in a general way with the *Metalegoceras jacksoni* beds of the Irwin River Coalfield (Western Australia), the Bitauni beds of Timor, and the Artinsk sandstone of the Urals. These beds are generally regarded as being of about the same age as the Leonard formation of western Texas.

SYSTEMATIC DESCRIPTIONS

Genus THALASSOCERAS Gemmellaro

THALASSOCERAS WADEI Miller, n. sp.

Plate 92, figures 8–12

This species, which is named in honor of Dr. Arthur Wade, is based on two internal molds, both of which are septate throughout. Neither of these is particularly well preserved or very complete, but they supplement each other very well and together elucidate most of the essential characters of the species.

Conch sublenticular, ammoniticonic, and moderately large; phragmacone (which consists of at least seven volutions) attains a maximum diameter, measured across the umbilicus, of at least 40 mm. (estimated), and living chamber is at least one-fifth volution in length. Whorls at maturity are compressed, broadly rounded laterally, rather narrowly rounded ventrally, and impressed dorsally. At adoral end of larger syntype (that is, about four-fifths of a volution apicad of adoral end of phragmacone of this specimen) conch is about 11½ mm. high and 10 mm. wide and is impressed dorsally to a depth of about 5 mm. At adapical end of outer volution of this specimen conch is about 5 mm. high and 5½ mm. wide and is impressed to a depth of about 2 mm.; and one volution apicad of this point it appears to be about 2 mm. high and 2½ mm. wide. As is indicated by these measurements, early volutions of conch are wider than high but during ontogenic development conch expands more rapidly dorso-ventrally than laterally. Smaller syntype is somewhat crushed laterally and measurements of it more nearly accurate than those that can be obtained from the accompanying illustration would have little significance.

At maturity umbilicus is small, closed, and rather inconspicuous; nevertheless diameter of umbilicus of smaller syntype is equal to about one-fourth that of specimen. Umbilical shoulders low and

rounded. No trace of growth-lines or surface ornamentation of any kind is discernible on either of the syntypes.

Septa numerous and camerae are, therefore, short. Only the general form of the immature sutures can be ascertained from the syntypes, but at maturity each suture forms a large prominently divided ventral lobe, one pair of large external lateral lobes, a pair of small umbilical lobes, one pair of internal lateral lobes, and a dorsal lobe. The major prongs (secondary lobes) of the ventral lobe are relatively shallow and wide, and their adapical portion is divided into five small subangular tertiary lobes, the outer (dorsal) two of which are incipiently unequally bifid. The median saddle in the ventral lobe is somewhat smaller than the adjacent secondary lobes, and it is U-shaped but is divided centrally by a small depressed V-shaped tertiary lobe. The first lateral saddles of the external sutures are U-shaped but their sides are digitate. The first lateral lobes of the external sutures are asymmetrically V-shaped and are digitate. The details of the digitation of these lobes and saddles of the external sutures are shown by figure 12 on the accompanying plate, but attention should perhaps be called to the fact that the external lateral lobes are more or less bifid as the secondary saddles immediately ventrad of the apex of these lobes are relatively large. The external second lateral saddles are broad, low, asymmetrical, and broadly rounded. The lobes on the umbilical wall are broad, shallow, and digitate—they appear to be trifid. The second lateral saddles of the internal sutures are very broad, low, asymmetrical, and broadly rounded. The first lateral lobes of the internal sutures are more or less tongue-shaped and are acuminate. The first lateral saddles of the internal sutures are tongue-shaped and they are narrow and rounded. The dorsal lobe is pointed tongue-shaped and is considerably larger than the internal lateral lobes but smaller than the external lateral lobes. Siphuncle small, circular in cross section, and ventral and marginal in position.

Remarks.—This species is a typical representative of the genus *Thalassoceras*, and its sutures are distinctly more advanced than are those of *Prothalassoceras*. It is perhaps more closely related to *T. chabakowi* Voinova of the Artinsk sandstone of the Urals than to any other described species, but it can be readily distinguished from that form by the details of the digitation of the lobes and saddles of the external sutures. *T. phillipsi* Gemmellaro of the Sosio beds of Sicily is also close to the species under consideration, and, though its sutures as illustrated by Gemmellaro (1888) are distinctly more advanced than are those of *T. wadei* represented on the accompanying plate, it should be taken into consideration that the details of the external sutures of *T. wadei* are known from only one small specimen (the smaller syntype) which may not have reached full maturity. In *T. subreticulatum* Gemmellaro, also of the Sosio beds, the umbilicus is not closed. *T. dieneri* Smith of the Bitauni beds of Timor, *T. karpinskyi* Toumansky of the Mount Kichkhi-Burnu (Marta River) beds of Crimea and probably *T. microdiscus* Gemmellaro of the Sosio beds of Sicily and possibly the Trogkofel limestone of

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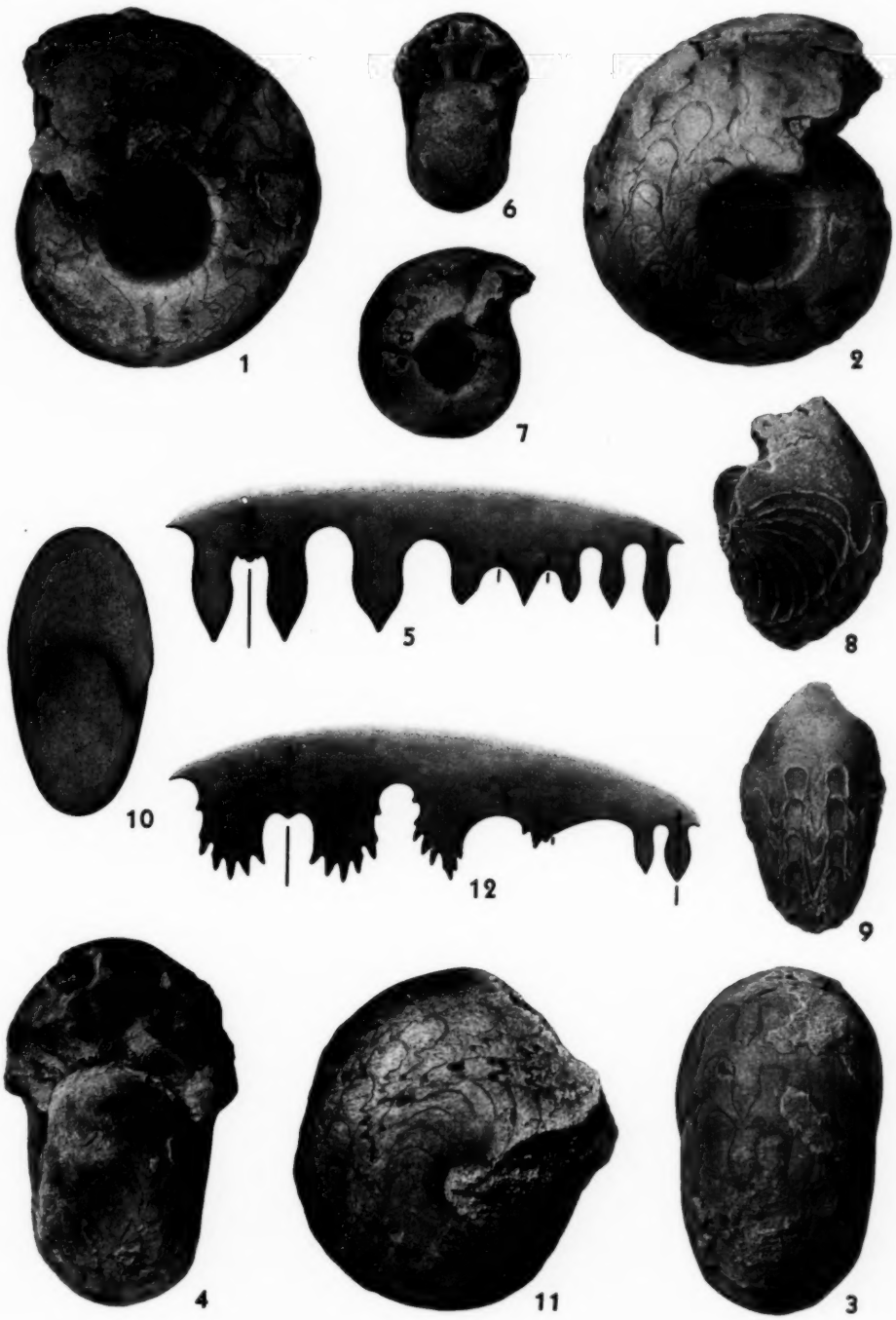
EXPLANATION OF PLATE 92

All specimens illustrated on this plate came from the "Lower Ferruginous series," 3 miles east of Nura Nura, Kimberley Division, Western Australia.

FIGS. *1–7*—*Metalegoceras clarkei* Miller, n. sp. The two syntypes, ×2, and a diagrammatic representation of one of the adoral sutures of the larger syntype, ×2½. (p. 687)

8–12—*Thalassoceras wadei* Miller, n. sp. The larger syntype (figs. *8*, *9*), to which the dorsal portions of the adoral volution of the phragmacone adhere, ×2; outline ventral view (a restoration) of the same specimen, ×2; the smaller syntype, ×4; and a diagrammatic representation of a complete suture, ×5. (p. 685)



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the Carnic Alps should all be referred to *Prothalassoceras*. Both of the type specimens of *T. microdiscus*, however, are very small and they may be immature representatives of *Thalassoceras*.

Occurrence.—"Lower Ferruginous series," 3 miles east of Nura Nura, Kimberly Division, Western Australia.

Types.—Geology Department, University of Western Australia.

Genus METALEGOCERAS Schindewolf

METALEGOCERAS CLARKEI Miller, n. sp.

Plate 92, figures 1–7

Conch subglobular, ammoniticonic, and at least moderately large. Both of the syntypes, rather well-preserved internal molds, are septate throughout, but the larger one attains a maximum diameter, measured across the umbilicus, of about 27 mm. Whorls depressed, rather broadly rounded laterally and ventrally, impressed dorsally, and helmet-shaped in cross section. At adoral end of larger syntype, conch is about 16 mm. wide and 12½ mm. high and is impressed dorsally to a depth of about 5 mm. At adapical end of outer volution of same specimen, conch is about 10 mm. wide and 6½ mm. high; as is indicated by these measurements, conch expands orad fairly rapidly and becomes less strongly depressed adorally. At adoral end of smaller syntype, which represents about six and one-half volutions of conch and which attains a maximum diameter (measured across umbilicus) of about 14½ mm., conch is about 9 mm. wide and 5½ mm. high and is impressed dorsally to a depth of about 2 mm. At adapical end of outer volution of this specimen, conch is about 5½ mm. wide and about 2½ mm. high.

Umbilicus rather small for this genus and at maturity its diameter is equal to about one-third that of specimen. Umbilicus of larger syntype attains a diameter of about 9 mm. whereas that of smaller syntype attains a diameter of only about 5½ mm., indicating that the umbilicus becomes relatively smaller during ontogenetic development. Umbilical shoulders subangular and distinct. Umbilical wall not straight but very broadly rounded, and it is inclined to adjacent portion of lateral side of conch at an angle of about 120 degrees.

Internal mold of conch marked at maturity by shallow rounded transverse constrictions of which there are four or five to the volution. These constrictions are slightly sinuous and form very shallow lateral and ventral sinuses and ventro-lateral and (on umbilical shoulders) dorso-lateral salients. On umbilical wall of smaller syntype the constrictions are very distinct, but on outer volution of larger syntype they can hardly be discerned dorsad of umbilical shoulders. Also, adoral constriction on larger syntype is much less prominent than preceding one. Umbilical walls of innermost volutions of conch are distinctly nodose, but those of outer volutions are smooth. Only faint traces of growth-lines can be discerned on syntypes, and I am somewhat uncertain as to their shape.

Septa rather closely spaced and camerae, therefore, rather short. Immature sutures not known, but at maturity each suture forms a large prominently divided ventral lobe and a smaller dorsal lobe, and between them five pairs of lobes and six pairs of saddles. Prongs (secondary lobes) of ventral lobe are pointed and are not quite symmetrical. Median saddle in ventral lobe is divided by three very small rounded or subangular lobes, the central one of which is distinctly larger than the lateral ones. First lateral saddle is large and is tongue-shaped but rounded. First lateral lobe is not quite as deep as ventral lobe and it is pointed tongue-shaped and is almost symmetrical. Second lateral saddle is U-shaped and is considerably lower than first lateral saddle. The next lobe (an adventitious lobe) is very asymmetrical and is more or less V-shaped though its sides or flanks are slightly sigmoidal. The next saddle, which is much lower than the second lateral saddle and is located on the umbilical shoulder, is depressed-U-

shaped. The next lobe (the umbilical lobe), which is located on the umbilical wall, is V-shaped and is just about as deep as the adjacent lobes. The next saddle, which is located on the umbilical seam, is relatively small and is asymmetrically U-shaped. The next lobe (an adventitious lobe), which is located well inside (dorsad of) the umbilical seam, is tongue-shaped but is curved. The second and first internal lateral saddles are tongue-shaped but rounded—the second is distinctly lower than the first. The first internal lateral lobe is relatively long and slender and is pointed tongue-shaped. The dorsal lobe is similar in shape to the first internal lateral lobe but is considerably deeper. The siphuncle is small, circular in cross section, and ventral and marginal in position.

Remarks.—This species is named in honor of Prof. E. de C. Clarke. Its relatively small umbilicus serves to distinguish it from most of the known congeneric forms. In *M. tschernyschewi* (Karpinsky) of the Artinsk sandstone of the Urals and possibly the Bitauni beds of Timor, the umbilicus is only slightly larger than is that of *M. clarkei*, but the sutures of the two forms are not precisely similar. *M. australe* (Smith) of the Bitauni beds seems to be very close to the species under consideration, but its umbilicus is slightly smaller and also its conch (like that of *M. tschernyschewi*) may attain a much greater size than that of *M. clarkei*. In *M. jacksoni* (Etheridge) of the Irwin River Coalfield (Western Australia) the sutures are more primitive than are those of *M. clarkei* in that, as was first pointed out by Thomas (1928), the pair of lobes just dorsad of the umbilical lobes are very small. Haniel (1915) apparently recognized the affinity of *M. jacksoni* with the Timor representatives of *Metalegoceras* for he concluded that the beds in which it occurs are Permian in age. Oyens (1933) has shown that there is almost complete gradation between the various species of *Metalegoceras* which J. P. Smith recognized from the Somohole and Bitauni beds of Timor; nevertheless the subdivisions employed by Smith seem to serve a useful purpose, though it is rather doubtful if they should be regarded as representing distinct species.

Occurrence.—"Lower Ferruginous series," 3 miles east of Nura Nura, Kimberley Division, Western Australia.

Types.—Geology Department, University of Western Australia.

ADDENDUM

Since this report was completed, Dr. Arthur Wade, who collected the fossils on which it is based, has written me (September 3, 1936) that the fact that I believe these specimens to be Middle Permian in age is "important . . . for they mark a break in the sequence, are associated with the highest known glacial deposits in the area and overlie the main glacial series. They tend to show, therefore, that, in this area at least, the main period of glaciation was that of the Lower Permian. This is an important conclusion if it can be substantiated."

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OSTRACODA OF THE GENERA *EUCYTHERE, CYTHERURA, EUCYTHERURA,* AND *LOXOCONCHA* FROM THE CRETACEOUS OF TEXAS

C. I. ALEXANDER

ABSTRACT

This paper contributes notes on the genera mentioned and describes two species of *Eucythere*, one (*E. brownstownensis*) of which is new; three new species of *Cytherura* (*C. cretacea, C. taylorensis, C. texana*); one species of *Eucytherura;* and three species of *Loxoconcha*, of which two (*L. brownstownensis, L. cretacea*) are new.

This is the third of a series of papers describing Ostracoda collected during the summer of 1933, with the assistance of a grant-in-aid from the National Research Council. The other two have been published in recent numbers of this Journal (Alexander, 1934, 1935).

The present paper describes Cretaceous species belonging to four genera of the family Cytheridae. One of these genera, *Eucytherura*, has been previously recognized only in the Recent seas, and another, *Eucythere*, has not been previously recorded from strata of Cretaceous age.

The localities from which samples used in this investigation were collected will be described in a separate section at the end of the paper. All illustrations were drawn by the author.

SYSTEMATIC DESCRIPTIONS

Genus EUCYTHERE Brady, 1866

Eucythere, G. S. BRADY, *1866*, A Monograph of Recent British Ostracoda, Linnean Soc. London, Trans., vol. 26, p. 429. Genotype, *Cythere declivis* NORMAN, *1865*, Reports on deep sea dredging on the Coasts of Northumberland and Durham, Nat. Hist. Trans. Northumb. and Durham, vol. 1, p. 16, pl. 5, figs. 9–12.

Shell in side view triangular in outline, highest at or near anterior end. Hinge margin straight or nearly so, ventral margin straight or slightly sinuate. Anterior end high, broadly rounded. Posterior end subacute to obtuse. Carapace usually widest behind middle.

The hinge structure is so weakly developed in most species that generic allocation is much more easily made on the basis of other shell structures.

The line of concrescence is at a moderate distance from, and parallel to, the outer margin of the shell. The inner margin is rather widely separated from the line of concrescence at the anterior end of the shell, but coincides with it elsewhere except for a very slight deviation at the posterior end. Radial pore-canals few in number, widely spaced, straight, narrow, simple. Normal pore-canals few in number, rather large and conspicuous.

This genus was originally established in the year 1865 by G. O. Sars under the name *Cytheropsis*, but as this name proved to be preoccupied, it was replaced the following year by that of *Eucythere*.

EUCYTHERE BRIGHTSEATENSIS (Berry)

Plate 93, figure 11

Cytheridea truncatus BERRY, *1925* (not *C. truncata* Jones, 1893), Am. Jour. Sci., ser. 5, vol. 9, p. 485, fig. 6.

Cytheridea truncata ALEXANDER, *1929*, Texas Univ., Bull. 2907, p. 74, pl. 5. fig. 16.
Cytheridea brightseatensis BERRY, *1933*, Jour. Paleontology, vol. 7, p. 112.

This species, described by Berry from the Monmouth formation of Maryland, and recorded by Alexander from the Navarro of Texas, was renamed by Berry when the name under which it was originally established was found to be preoccupied. A single valve of the species has been found which was sufficiently well preserved and clean enough for examination with transmitted light. The characters of inner margin, line of concrescence and the pore-canals (pl. 93, fig. 11) indicate what the shape of the carapace suggests, that the species is a true representative of the genus *Eucythere*.

Hypotype collected at station 24148.

EUCYTHERE BROWNSTOWNENSIS
Alexander, n. sp.
Plate 93, figure 4

Carapace in side view triangular in outline, highest at anterior end. Dorsal margin very slightly convex along hinge line, sloping steeply downward posteriorly. Ventral margin slightly sinuate. Anterior end broadly and evenly rounded. Posterior end narrow, obtusely rounded. In dorsal view, subovate, widest slightly behind middle.

Length of holotype, 0.57 mm.; height, 0.32 mm.

Holotype collected at station 24124.

Genus CYTHERURA Sars, 1865

Cytherura, SARS, G. O., *1865*, Oversigt af Norges marine Ostracoder, p. 69. Genotype *Cythere gibba* O. F. MULLER, *1785*, Entomostraca, p. 66, pl. 7, figs. 7–9.

Shell small, elongate, subquadrate. Dorsal margin straight or gently convex, ventral margin straight or slightly sinuate; dorsal and ventral margins subparallel. Anterior end rounded, posterior end bearing a small, compressed, obtuse caudal process. Surface of valves smooth or slightly reticulate, often with longitudinal ridges or folds, which in some cases are elevated to form sharp keels.

Inner margin and line of concrescence coincide throughout their course. The area of concrescence is broad at both the anterior and posterior ends, and in many species actually comprises the greater portion of the shell. The line of concrescence approaches the outer margin only along the ventral edge, and characteristically forms a posteriorly directed loop in the postero-ventral region. Corresponding to the width of the area of concrescence, the radial pore-canals are extraordinarily long; they are simple and slender, with a slight bulbous enlargement near their distal ends (pl. 93, fig. 10).

Müller (1894) describes the hinge structure as consisting of two teeth in each valve, one at each end of the hinge line,

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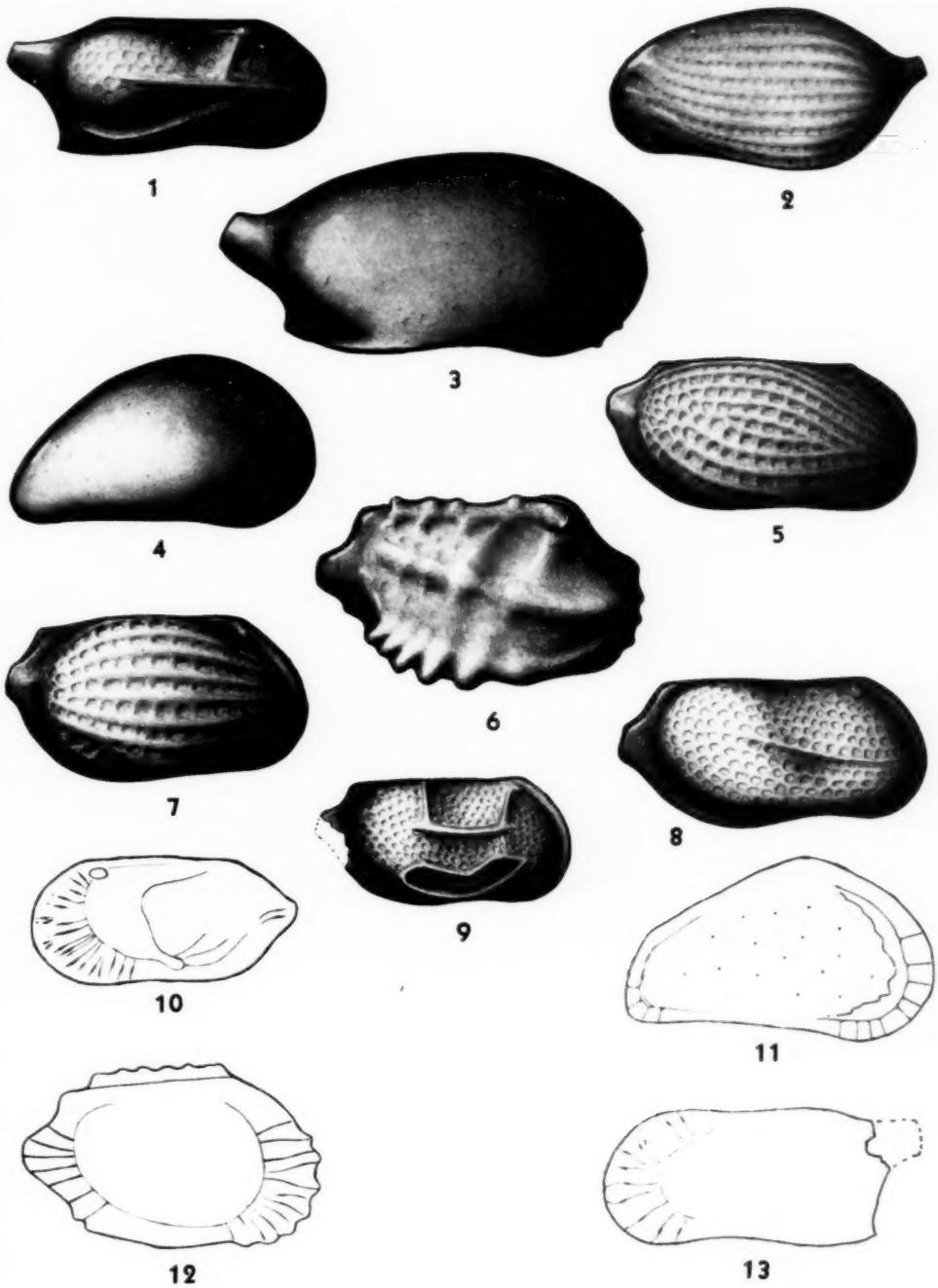
EXPLANATION OF PLATE 93

FIGS. *1, 13—Cytherura cretacea* Alexander, n. sp. *1*, Right valve view, ×120. *13*, Left valve by transmitted light, showing inner margin and radial pore-canals, ×120. (p. 691)
2—Cytherura taylorensis Alexander, n. sp. Left valve view, ×120. (p. 691)
3—Cytherura texana Alexander, n. sp. Right valve view, ×120. (p. 691)
4—Eucythere brownstownensis Alexander, n. sp. Right valve view, ×75. (p. 690)
5, 7—Loxoconcha cretacea Alexander, n. sp. *5*, Right valve view of male, ×100. *7*, Right valve view of female, ×100. (p. 693)
6, 12—Eucytherura chelodon (Marsson). *6*, Right valve view, ×100. *12*, Right valve by transmitted light, showing inner margin and radial pore-canals, ×100. (p. 692)
8—Loxoconcha fletcheri Israelsky. Right valve view, ×100. (p. 693)
9—Loxoconcha brownstownensis Alexander, n. sp. Right valve view, ×100. (p. 694)
10—Eucythere reticulata G. W. Müller, redrawn from the original, omitting surface sculpture and showing inner margin and radial pore-canals, ×80.
11—Eucythere brightseatensis (Berry). Right valve by transmitted light, showing line of concrescence, inner margin (partially destroyed), and pore-canals, ×75. (p. 689)



Alexander, Cretaceous Ostracodes

UNIV. OF MICH.

the anterior one of the left valve fitting behind the anterior tooth of the right valve, and the posterior tooth of the left valve fitting in front of the posterior tooth of the right valve.

The shells of species of this genus are so small, and the shape and other features of the structure so distinctive, that generic determination is much more easily and certainly made on the basis of other features than on hinge structure.

Jones (1870) assigned the species he originally described as *Cytherella? appendiculata* (Jones, 1849, p. 32, pl. 6, fig. 21) to the genus *Cytherura*. The figures of this species are not entirely satisfactory, but if this generic assignment is correct, this species is the only previously known Cretaceous representative of the genus *Cytherura*. The species described by Israelsky (1929) under the name *Cytherura spooneri* is clearly not a *Cytherura*, and has subsequently (Alexander, 1933) been assigned to the genus *Monoceratina*.

CYTHERURA CRETACEA Alexander, n. sp.
Plate 93, figures 1, 13

Carapace in side view distinctly elongate, subquadrate. Dorsal margin straight. Ventral margin slightly sinuate near middle, with strong, posteriorly projecting postero-ventral angle. Anterior end slightly obliquely rounded, posterior end with narrow, compressed, obtuse caudal process slightly below postero-dorsal angle. Surface of valves finely ornamented with numerous small, shallow pits, the low ridges between these pits forming a reticular pattern, and with four conspicuous, longitudinally disposed ridges. One of these arises at the small anterior cardinal tubercle and extends backward just beneath the dorsal edge of the shell, terminating near the posterior cardinal angle. A second arises a short distance behind the middle of the ventral margin and extends backward and very slightly upward, becoming obsolete at about one-third the length of the carapace from the posterior end. A third ridge arises slightly below the median ridge, and at a point about one-fifth the length of the carapace from the anterior end, curves downward and backward and approaches the ventral edge a short distance in front of the postero-ventral angle, then bends upward in a broad curve, becoming obsolete a short distance in front of the lower edge of the caudal process. The fourth longitudinal ridge is shorter than the others, and pursues a somewhat irregular course along the lower surface of the anterior half of the shell. A low, short, transverse ridge extends from the anterior cardinal region to about the middle of the median longitudinal ridge.

Length of holotype, 0.37 mm.; height, 0.16 mm.

This species has been collected at a few exposures of Navarro and upper Taylor clays. Holotype collected at station 24148.

CYTHERURA TAYLORENSIS Alexander, n. sp.
Plate 93, figure 2

Carapace in side view elongate, subquadrate, and approaching an ovate outline, highest slightly behind the middle. Dorsal margin gently arched, sloping somewhat more steeply toward the posterior than toward the anterior end. Ventral margin straight. Anterior end slightly narrowed, evenly rounded. Posterior end tapering abruptly, with compressed caudal process slightly above the middle. Surface ornamented with numerous small, shallow pits, which are arranged in narrow, longitudinally disposed furrows with low, rounded ridges between.

Length of holotype, 0.37 mm.; height, 0.19 mm.

This species has been collected only at the type locality, station 24149.

CYTHERURA TEXANA Alexander, n. sp.
Plate 93, figure 3

Carapace in side view subquadrate, highest anteriorly. Dorsal margin gently arched. Ventral margin sinuate slightly in front of middle, terminating in a prom-

inent, subacute postero-ventral angle. Anterior end broadly and evenly rounded. Posterior end with a rather broad caudal process slightly above the middle. Surface almost smooth, bearing small, shallow, indistinct, discrete pits, and a strong ventro-lateral keel.

Length of holotype, 0.49 mm.; height, 0.23 mm.

This species has been collected only at the type locality, station 2494.

Genus EUCYTHERURA Müller, 1894

Eucytherura, MÜLLER, G. W., *1894*, Die Flora und Fauna des Golfes von Neapel, Mon. 21, Ostracoda, p. 305. Genotype, *Cythere complexa* BRADY, *1867*, Report on Ostracoda dredged amongst the Hebrides, p. 210.

Small Ostracoda, with relatively thick and heavy shells. Carapace in side view short, quadrate. Dorsal margin straight or very slightly irregular. Ventral margin straight or slightly convex, roughly paralleling the dorsal margin. Anterior end bluntly rounded, in many species almost squarely truncated. Posterior end produced to form a short, compressed caudal process.

Müller describes the hinge structure as consisting of "anterior and posterior teeth in the right valve." The hinge structure of the Cretaceous species referred to this genus, *E. chelodon* (Marsson), is indistinguishable from that of *Cythereis*.

Inner margin and line of concrescence coincide throughout and run parallel to, and at a moderate distance from, the outer margin of the shell. Radial pore-canals few in number, isolated from each other, simple, straight or very slightly irregular in their course.

EUCYTHERURA CHELODON (Marsson)

Plate 93, figures 6, 12

Cythere chelodon MARSSON, *1880*, Mitt. Naturwiss. Ver. von Neu-Vorpommern und Rügen in Greifswald, p. 43, pl. 3, figs. 13 *a–f*.
Cytherura? dubia ISRAELSKY, *1929*, Arkansas Geol. Survey, Bull. 2, p. 6, pl. 4 A, fig. 6.

Carapace in side view subquadrate in outline, short, highest at anterior end. Dorsal margin straight. Ventral margin slightly convex downward. Dorsal and ventral margins subparallel, converging slightly posteriorly. Anterior end bluntly and slightly obliquely rounded. Posterior end with short, blunt, compressed caudal process, slightly above the middle. Surface ornamented by a few small, shallow, discrete pits, and by three prominent, longitudinally disposed ridges. One of these ridges lies along the dorsal margin, between the small, rounded, anterior cardinal tubercle and the subacute, postero-dorsal angle. Another ridge rises on the lateral surface of the valve, a short distance above the antero-ventral angle, extends in a gentle curve backward and downward to the ventral margin, and continues along the margin of the shell to the postero-ventral angle. Both the dorsal and ventral ridges bear a few small tubercles, those along the posterior two-thirds of the ventral ridge being somewhat larger and higher than those of the dorsal ridge. The third ridge arises at a point slightly above the anterior end of the ventral ridge, extends obliquely backward and slightly upward, and terminates a short distance below the posterior end of the dorsal ridge. This median ridge, like the other two, bears a few low tubercles, with two larger ones, one on each side of a shallow notch near the middle of the ridge.

Length of hypotype, 0.44 mm.; height, 0.26 mm.

This species, recorded by Israelsky under the name *Cytherura? dubia* from the Saratoga chalk, has been observed by me in the Annona and Ozan formations of Arkansas, and in the equivalent Taylor strata and in the Brownstown of Texas. A closely allied (possibly identical) species from the Upper Cretaceous chalk of Norwich, was referred by Jones (1849, p. 17, pl. 2, fig. 8 *a*, *b*) to *Cythereis macropthalma* (Bosquet), and was redescribed as a new species under the name *Cythereis icenica* by Jones and Hinde (1890) when they decided that Jones' original identification was erroneous.

Hypotype collected at station 24124.

Genus LOXOCONCHA

Loxoconcha, SARS, G. O., Oversigt af Norges marine Ostracoder, p. 61. Genotype, *Cythere impressa*, BAIRD, *1850*, Natural History of British Entomostraca, p. 175, pl. 21, fig. 9; synonym, *Loxoconcha rhomboidea* Sars, 1865.

Shell rhomboidal to quadrate in outline. Dorsal margin straight, with distinct, rounded antero- and postero-ventral angles. Ventral margin straight or somewhat flexuous, curving upward posteriorly to the short, blunt, compressed caudal process, which is situated above the median longitudinal line of the shell. Postero-ventral edge of valves bears a narrow, compressed, blade-like keel. Anterior end rounded. Surface of valves usually pitted or reticulate, in some species smooth. In most species a small, distinct anterior cardinal tubercle is present.

The hinge teeth are rather weakly developed in most Cretaceous species. The development of the hinge structure of this genus from Cretaceous to Recent time is described in detail in my recent paper (Alexander, 1934, p. 223, pl. 34, figs. 7, 8) on the Ostracoda of the Midway (Eocene) of Texas.

The line of concrescence is at a moderate distance from the outer margin of the shell at the anterior and posterior ends, and lies much nearer the outer margin along the ventral edge. The inner margin and the line of concrescence coincide or deviate but slightly throughout. Radial pore-canals only moderately numerous, slender, straight, simple.

LOXOCONCHA FLETCHERI Israelsky

Plate 93, figure 8

Loxoconcha fletcheri ISRAELSKY, *1929*, Arkansas Geol. Survey, Bull. 2, p. 11, pl. 2 *a*, figures 2, 3.

Shell in side view quadrate, distinctly elongate, highest behind middle. Dorsal margin straight. Ventral margin gently sinuate slightly in front of middle, curving upward posteriorly to the short, blunt, caudal process. Anterior end evenly rounded, with narrow, compressed border. Surface of valves finely and strongly reticulate, and with a slight but distinct depression near the center. A short, low, narrow, slightly oblique, longitudinally disposed ridge crosses this depression slightly above the middle of the shell, and blends into the reticular pattern at each end. Carapace strongly convex, widest in posterior half.

Length of hypotype, 0.4 mm.; height, 0.2 mm.

This species is widely distributed in the Taylor formation of Texas, and in the equivalent strata in Arkansas.

Hypotype collected at station 24149.

LOXOCONCHA CRETACEA Alexander, n. sp.

Plate 93, figures 5, 7

Carapace in side view quadrate, somewhat elongate, of nearly equal height throughout. Dorsal margin straight. Ventral margin very gently sinuate slightly in front of middle, curving gradually upward posteriorly to the short, obtuse, caudal process. Anterior end broadly and slightly obliquely rounded, with narrow, compressed border. Surface of valves with strong, rounded, slightly oblique and slightly irregular, longitudinally disposed ridges, the furrows between the ridges each with a row of small but distinct pits. Valves strongly convex, widest at middle.

Carapace of male somewhat narrower and less strongly convex than that of female.

Measurements of syntypes: female, length 0.4 mm., height 0.22 mm., width 0.22 mm.; male, length 0.42 mm., height 0.2, width 0.17 mm.

Well developed representatives of this species have been observed only in the Navarro. A few specimens with similar but much weaker markings have been found in one outcrop of Taylor clays, but it is impossible to determine from the few individuals available whether the apparent weakness of the ornamentation is due to erosion of the shells, or whether it is actually characteristic of the Taylor specimens.

Syntypes collected at station 24148.

LOXOCONCHA BROWNSTOWNENSIS
Alexander, n. sp.
Plate 93, figure 9

Carapace in side view quadrate, of equal height throughout. Dorsal margin straight. Ventral margin nearly straight, very slightly sinuate in front of middle, curving upward posteriorly to the short, blunt, narrow caudal process. Anterior end bluntly and obliquely rounded. Surface of valves finely and strongly reticulate, bearing a number of low, narrow, but distinct ridges. A short, slightly oblique, vertical ridge extends downward and slightly backward from the small anterior cardinal tubercle, and at a point slightly above the median line joins the anterior end of a longitudinal ridge which terminates posteriorly at a point about one-third the length of the carapace from the posterior end. A second vertical ridge extends from the posterior end of the longitudinal ridge upward and slightly backward to the dorsal edge of the shell. These ridges enclose a broad, shallow depression on the valve-surface. Two curved, subparallel, longitudinally disposed ridges are situated on the ventro-lateral surface of the valves, and are united at their ends by short, transverse ridges to form a long, narrow, arched loop which approaches the ventral edge of the shell near the middle and bends upward at each end.

Length of holotype, 0.34 mm.; height, 0.17 mm.

This species has been collected at a few outcrops of the Brownstown marl in northeast Texas and in Arkansas.

Holotype collected at station 24119.

LOCALITIES

STATION 2494. Upper Navarro clays, exposed in a roadside ditch, 4.7 miles west of the bridge over Medina River on the Castroville-Hondo highway. The holotype of *Cytherura texana*, n. sp., was collected at this locality.

STATION 24119. Upper Brownstown clays, exposed in the west bank of High Creek, about 20 feet south of the bridge which crosses the High Creek, on the Paris-Bonham highway. The holotype of *Loxoconcha brownstownensis*, n. sp., was collected at this locality.

STATION 24124. Lower Brownstown clays, exposed in a deep roadside ditch west of the Honey Grove-Monkstown road, 4 miles north of the town square in Honey Grove. The holotype of *Eucythere brownstownensis*, n. sp., and the hypotype of *Eucytherura chelodon* (Marsson) were collected at this locality.

STATION 24148. Lower Navarro clays, exposed in a high bluff on the right bank of Onion Creek, just east of the bridge at Jones' crossing on the Austin-Bastrop road. (Texas Bur. Econ. Geology Loc. No. 226-T-9, Texas Univ., Bull. 3101, p. 121, 1931). The syntypes of *Cytherura cretacea*, n. sp., and of *Loxoconcha cretacea*, n. sp., and the hypotype of *Eucythere brightseatensis* (Berry) figured in this paper, were collected at this locality.

STATION 24149. Upper Taylor clays, exposed on the right bank of Onion Creek, near the bridge at Moore and Berry's crossing, 8.5 miles, in a straight line, southeast of the State Capitol in Austin. (Texas Bur. Econ. Geology Loc. No. 226-T-8, Texas Univ., Bull. 3101, p. 121, 1931). The holotype of *Cytherura taylorensis* and hypotype of *Loxoconcha fletcheri* Israelsky were collected at this locality.

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C. I. ALEXANDER, LAKE CHARLES, LA. MANUSCRIPT RECEIVED BY THE EDITOR, MARCH 16, 1936.

JOURNAL OF PALEONTOLOGY, VOL. 10, NO. 8, PP. 695–703, PL. 94, TEXT-FIGS. 1*a–p*, 2, DECEMBER, 1936

SHELL STRUCTURE OF THE OSTRACODE GENUS *CYTHERIDEA*

MORTON B. STEPHENSON

ABSTRACT

American Tertiary species of *Cytheridea* are, for the greater part, divisible into two groups, each of which is distinct from the type species. The diagnostic shell characters of *Cytheridea*, as revealed by a detailed study of the genotype, *C. mülleri* (Münster), are described. Two new subgenera, *Haplocytheridea* and *Clithrocytheridea*, are erected to receive a number of species originally referred to *Cytheridea*. One new species, *Cytheridea* (*Haplocytheridea*) *blanpiedi*, and one new variety, *Cytheridea* (*Clithrocytheridea*) *grigsbyi* var. *vicksburgensis*, are described from the Oligocene of the Gulf Coast.

In spite of the fact that numerous species of the genus *Cytheridea* occur in Tertiary sediments of the Gulf Coast, little use has been made of them for purposes of stratigraphic correlation. The limited number of described species has undoubtedly made the problem of their utilization more difficult, and the confusion existing in the literature as to the exact characteristics of the genus has been responsible for many incorrect assignments. Superficial peculiarities in general shape and surface ornamentation are often considered to be diagnostic for generic placement. Alexander (1933, p. 186) has noted an instance of this in the number of species of *Cytheropteron* which have been erroneously referred to *Cytheridea*, due to strong similarity in their hinge structure.

The present paper is an attempt to clarify views regarding *Cytheridea* through a detailed account of the shell structure as revealed in a careful study of the genotype, *C. mülleri* (Münster). The subgenera here proposed include a large number of species in the American Tertiary section described under the genus *Cytheridea*, the shell structure of which is distinct from the genotype as originally defined. In maintaining the genus, I consider it necessary at the outset to present an historical summary as a background.

HISTORY

The first reference to the genotype of *Cytheridea* is found in a paper by Münster (1830). Listing the species as *Cythere müllerii*, it was described as having been found at Osnabrüch, Cassell, Paris, and Bordeaux, the valves being entirely smooth and slightly reniform, like those of *Cythere lutea* (Müller). This rather vague original description was amplified by Roemer (1838). The shell was redescribed as "longish oval, bow-shaped at the top, almost even beneath, nearly cylindrical, finely toothed on the rear edge, covered everywhere with round, shallow pits." Roemer's drawings of the species, which are rather poor, are reproduced on Plate 94, figures 13 and 14.

While this was a distinct advance over the work of Münster, it soon became evident that a more detailed account of the shell structure was necessary to insure proper generic assignments. It remained for Bosquet (1852) to describe the species more fully, which he did in 1850 (1852), setting up the genus *Cytheridea*, and describing a number of species under

the genus. Bosquet indicated the typical hinge structure of the genus to consist of two series of 6 to 8 small teeth near the two extremities of the dorsal side of the right valve, with corresponding depressions in the opposite valve. *C. mülleri* was characterized as being rounded anteriorly with several small teeth, the posterior border narrow, obtuse, with several similar teeth. An arched dorsal margin was noted, and a straight, slightly sinuate ventral margin. The ornamentation was described as a large number of concave points, at the bottom of which were inserted fragile, hair-like projections, arranged in 4 or 5 furrows parallel to the anterior and pectoral regions.

The genus was maintained by Sars (1865), who noted that, on the basis of fossil forms, *Cytheridea* is very close to the genus *Cyprideis*, but nevertheless shows certain distinctive characters. Two distinct species were studied by Sars, one of which was stated to be very close to *Cytheridea mülleri*, and both were reported from "our younger glacial formation."

Until the year 1889, the genus was apparently upheld on the basis of general descriptions, but in that year Brady and Norman (1889) definitely indicated *Cytheridea mülleri* as the genotype. This was followed by Müller (1894), who gave a rather generalized generic description, indicating the hinge of the right valve to be made up of two teeth, the muscle scars a row of four with at least one in front of them.

Lienenklaus (1900) reported the genotype from the lower Oligocene of Lattorf and the upper Oligocene of Wiepke. Lower Oligocene specimens were found to be smaller, in dorsal view less flattened, with the ends less blunt than in the typical upper Oligocene form. The line of concrescence was fairly well removed from the outer margin, almost coinciding with the inner margin on the anterior, and never being more than one-quarter the width of the marginal zone away from the inner margin; marginal pore-canals fairly numerous, fine, and only rarely expanded, about 40 in number on the anterior.

The first detailed study of the hinge structure of the genus *Cytheridea* available to the author was published by Zalányi (1913). Two general types of hinges were recognized among European species, determined by the extent of development of the teeth in the right valve. The first type was referred to as the uninterrupted or total, and the second the restricted or partial type, the former being interpreted as probably the simpler form. The uninterrupted row of teeth (figs. 2*a*, *b*) was given as the common form, while the partial row (figs. 2*g*, *h*) was observed in only a few instances. Between these two types, numerous transition forms were noted (figs. 2*c–f*), the continuous row of teeth sustaining a gradual reduction and becoming isolated in elliptical cavities at the two ends of the hinge margin.

EXPLANATION OF TEXT-FIGURE 1

a, *b*—*Cytheridea* (*Clithrocytheridea*) *grigsbyi* Howe and Chambers. *a*, Hinge of left valve; *b*, hinge of right valve. (p. 703)

c, *d*, *i*—*Cytheridea* (*Clithrocytheridea*) *grigsbyi* Howe and Chambers var. *vicksburgensis* Stephenson, n. var. *c*, Hinge of left valve; *d*, hinge of right valve; *i*, muscle scar pattern, right valve. (p. 703)

e, *f*, *m*, *n*—*Cytheridea* (*Haplocytheridea*) *blanpiedi* Stephenson, n sp. *e*, Hinge of left valve; *f*, hinge of right valve; *m*, *n*, anterior and posterior marginal areas of right valve, showing marginal pore-canals. (p. 701)

g, *h*, *j*, *k*—*Cytheridea* (*Haplocytheridea*) *montgomeryensis* Howe and Chambers. *g*, Dorsal view of hinge structure; *h*, muscle scar pattern, left valve; *j*, *k*, posterior and anterior marginal areas of a left valve. (p. 700)

l, *o*, *p*—*Cytheridea* (*Clithrocytheridea*) *garretti* Howe and Chambers. *l*, Dorsal view of hinge structure; *o*, *p*, posterior and anterior marginal areas of a left valve. (p. 702)

All figures ×75.

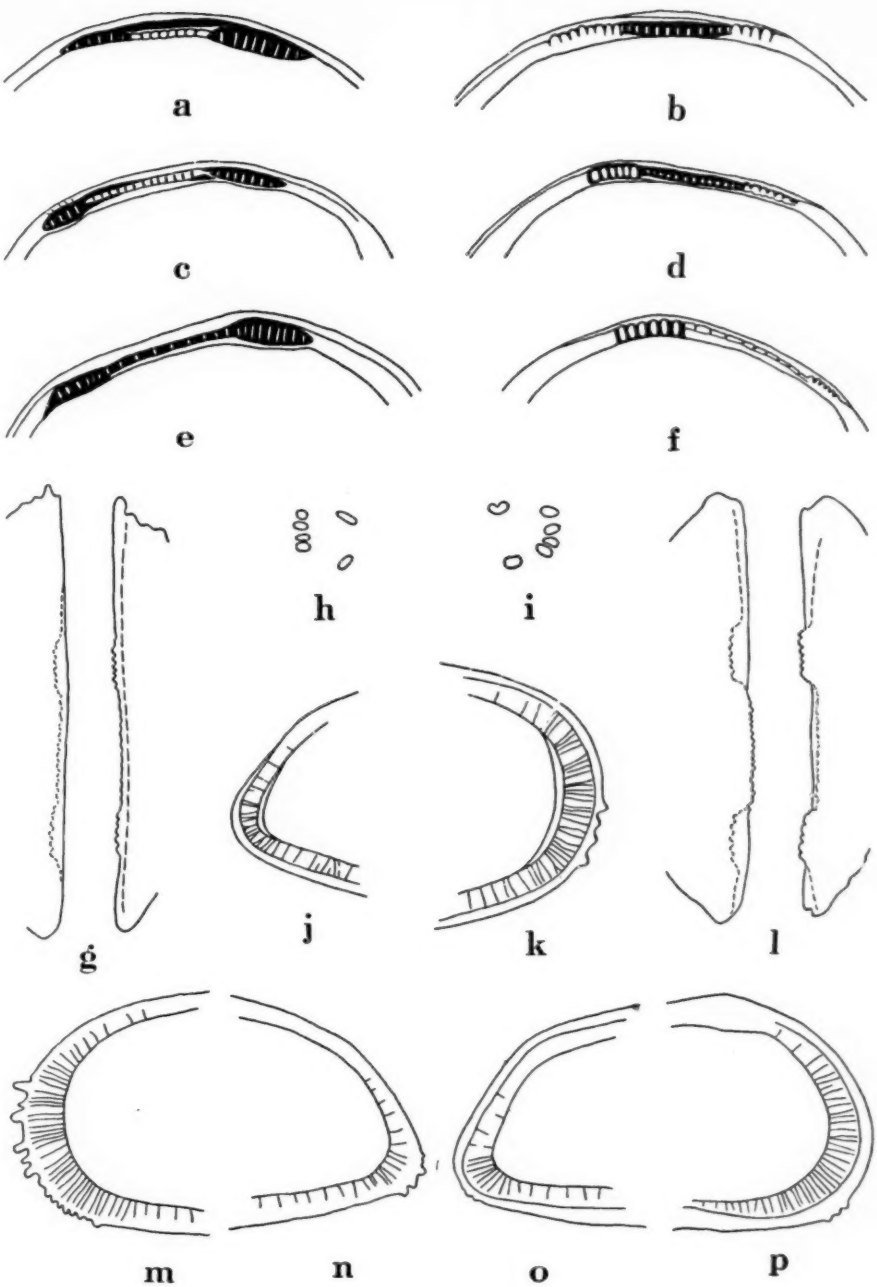


FIG. 1

In his classic work on the Crustacea, Sars (1925) indicated the characteristics of *Cytheridea*. The carapace was described as

> more or less reniform in shape and rather solid, with more or less conspicuous flattened tubercles. Valves only slightly unequal, with the edges unarmed; marginal zone rather narrow, and densely striated, inner duplicatures broader than in *Cyprideis*.

The hinge was said to be similar to that of *Cyprideis*, which Sars noted as "exhibiting a more or less distinct crenulation of the edges." The discussion is essentially zoological in nature, and deficient in detail concerning the carapace itself. I disagree with Sars where he indicates *Cytheridea papillosa* as the type of the genus, and in referring to the genotype will follow Brady and Norman in their previously mentioned selection of *C. mülleri* (Münster).

The discussion of the hinge structure of the genus *Cytheridea* given by Alexander (1933, p. 89, pl. 26, figs. 4*a*, *b*) seems to have been derived from American species, as *C. globosa* Alexander is figured as typical for the genus. The hinge in the right valve, with terminal teeth and finely denticulate connecting bar, and left valve with sockets and groove, is here classed as typical for the subgenus *Haplocytheridea*, but distinct from and simpler than the hinge of the genotype.

A recent addition to our knowledge of the genus is to be found in the excellent paper by Van Veen (1935). The hinge indicated appears to agree with that designated for the new subgenus *Haplocytheridea*, although I have not examined the species upon which it is based. The anterior and posterior dental areas of the right valve were described as connected by a slender very finely notched bar. The left valve was equipped with corresponding notched sockets, connected by a long, very slender, notched furrow, in which the bar of the right valve lay. Above the furrow, a very slender bar was separated from the dorsal margin of the valve by a second furrow. The conclusion is reached that no part of the right valve lies in the furrow of the left valve between the bar and the dorsal margin. Van Veen has pointed out to me (letter dated Feb. 1, 1936) that the species of *Cytheridea* described in the paper probably belong to different genera, a fact which could not be verified because of the state of preservation of the material.

Several occurrences of *C. mülleri* (Münster) have been recently reported. Stadnichenko (1927) indicated the presence of the species in the Crockett (so-called Yegua) Eocene of Texas. I have specimens from Evergreen Crossing (topotypes from the original sample obtained from Wade H. Hadley, Jr.), and find that, as Alexander (1934) has shown, figured specimens are of two distinct species. The tuberculate form is close to *C. wallacei* Howe and Garrett (1934) from the Sabine (Wilcox) Eocene of Louisiana, and shows the characteristic hinge structure of the subgenus *Haplocytheridea*. The hinge of the punctate species possesses a high, notched bar between the terminal sockets of the left valve, and should be assigned to the subgenus *Clithrocytheridea*. I agree also with Alexander (1934) that specimens referred to the genotype by Cushman (1925) from the Eocene of Mexico are identical with the punctate species of Stadnichenko. Topotypes of this species were presented to me by J. A. Cushman.

Acknowledgments.—I am deeply indebted to Dr. Henry V. Howe, Director of the School of Geology, Louisiana State University, for his guidance and many suggestions, which have added materially to this study. I wish especially to thank Dr. C. I. Alexander, Magnolia Petroleum Company, Lake Charles, La., Dr. J. A. Cushman, Sharon, Mass., and Dr. A. Franke, Arnstadt, Germany, all of whom supplied material from the type locality of *C. mülleri* without which this study would have been impossible. Doctor Franke has also kindly presented me

with beautifully preserved specimens of the genotype from the middle Miocene of Germany.

The type specimens of the new species described in this report have been deposited in the H. V. Howe Collection, Louisiana State University, Baton Rouge, Louisiana. The localities from which these specimens were collected are described at the end of the paper.

SYSTEMATIC DESCRIPTIONS

Family CYTHERIDAE Baird, 1850

Genus CYTHERIDEA Bosquet, 1850 (1852)

Subgenus CYTHERIDEA (Bosquet)

Genotype CYTHERIDEA MÜLLERI (Münster)
Plate 94, figures 1, 2, 7

Cythere müllerii MÜNSTER, *1830*, Jahrb. für Mineral Geog. Geol. Petrefackt., p. 63.
Cytheridea mülleri BOSQUET, *1850* (1852), Acad. royale sci. Belgique, Mem., vol. 24, p. 39, pl. 2, fig. 4.

Carapace tumid, thickest at about the middle. In side view elongate, subovate, highest just anterior to the middle; left valve larger than the right, overlapping around the entire margin, with the least overlap at the anterior and posterior ends. Dorsal margin arched, tending to become somewhat angular at the two denticular areas; ventral margin nearly straight, slightly incurved and flanged just anterior to the middle, the flange in the right valve fitting inside the flange in the left valve. Anterior end obliquely rounded in the left valve, and more or less evenly rounded in the right valve, bearing about six short spines in each valve, which are more prominent in the right valve. Posterior end obliquely truncate, with blunt postero-ventral angle. Entire surface coarsely and more or less regularly punctate, roughly conforming to the outer margins. Interior of the valves smooth, with the inner margin of the inner lamella coinciding with the line of concrescence except for a short distance at the anterior end. Marginal area rather broad, having a maximum width of 0.09 mm. at the end. Radial pore-canals fairly numerous, about forty on the anterior, simple, narrow and slightly wavy, of about uniform diameter, somewhat irregularly spaced. Muscle scars somewhat obscured, although a vertical row of four, the uppermost somewhat removed, was visible on one specimen.

The hinge structure in the left valve is composed of four distinct segments. The first of these is an elongate, elliptical, anterior socket which is rather deeply incised, being deeper at the anterior end, and notched by about six transverse grooves. Its length is approximately 0.12 mm., and its height 0.025 to 0.03 mm. The dorsal margin strongly overhangs the socket. Behind the socket is a high, finely crenulate bar, maintaining a fairly uniform height throughout. The bar has a broad base, and its smooth, obliquely truncate ends form distinct triangular slopes. The crest of the bar has a length of 0.08 to 0.09 mm., and a width of about 0.01 mm. This bar is separated from the dorsal margin by a faintly incised line which marks a change in slope, and is separated from the third element of the hinge—a somewhat lower, narrower bar—by a diamond-shaped depression or notch, which has a length of 0.05 mm. The notch is formed by the oblique truncation of the ends of the bars. The third element of the hinge is a low, elongate, narrow, finely crenulate bar. It is highest at its anterior end, and its posterior end does not project beyond the edge of the dorsal margin when viewed from above, but it is nevertheless a distinct bar, separated from the dorsal margin by a narrow incised groove which becomes deeper posteriorly. This bar is slightly more removed from the dorsal margin than the anterior bar. It is obliquely truncate at both ends, which form smooth triangular faces. The crest of the bar has a length of 0.10 mm., and a width of about 0.01 mm. The fourth

element is a deeply incised posterior socket which is elongate oval in shape, crossed by five or six transverse trenches, and is strongly overhung by a lobe of the dorsal margin. It is somewhat shorter than the anterior socket, and has a length of 0.10 mm. and a width of about 0.02 mm.

The hinge in the right valve is likewise composed of four segments. The anterior dental area consists of about six teeth, separated by definite, parallel notches, and extending from the outer to the inner edge of the dorsal margin, being most prominent at the outer edge. The hinge between the two terminal dentitions is composed of subequal portions corresponding to the two central segments of the left valve. Immediately behind the anterior dentition lies a finely notched groove, deepest anteriorly, and overhung by the edge of the dorsal margin. About the middle of the hinge the fine crenulations become confluent with the edge of the dorsal margin, and continue thus as the notched edge of the dorsal margin to the posterior dental area. The fourth element is the posterior dental area, an elongate, narrow line of about five teeth separated by transverse grooves, and extending from the outer edge of the dorsal margin nearly to its inner edge, being most prominent near the inner edge. In dorsal view the terminal segments, i.e., the anterior and posterior dentitions, project strongly beyond the edge of the dorsal margin; the dorsal portion of the anterior dentition and the ventral portion of the posterior dentition being most prominent.

Subgenus HAPLOCYTHERIDEA Stephenson, new subgenus

Subgenotype *Cytheridea montgomeryensis* Howe and Chambers.

This subgenus is very similar to the subgenus *Cytheridea* in most of its shell characters. The hinge structure, which is simpler than that of the typical *Cytheridea*, presents a ready means of separation. The hinge of the right valve is composed of two elongate, taxodont dental areas, each of which is divided into several cusps by transverse notches. Between these terminal dentitions, along the dorsal margin and separated from it by an almost imperceptible line, is a uniformly projecting line of equidimensional, minute crenulations. In the left valve the hinge possesses corresponding notched sockets, which are connected by a faint, narrow, longitudinal, crenulate incision that lies immediately below and beneath the projecting edge of the dorsal margin.

The two subgenera agree with respect to all other shell characters.

The range of *Haplocytheridea*, as shown by collections available to me, is Cretaceous to Recent.

CYTHERIDEA (HAPLOCYTHERIDEA) MONTGOMERYENSIS Howe and Chambers

Plate 94, figures 3, 4, 9; Text-figures 1 *g*, *h*, *j*, *k*

Cytheridea montgomeryensis HOWE and CHAMBERS, *1935*, Louisiana Dept. Cons., Geol.

EXPLANATION OF PLATE 94

FIGS. *1*, *2*, *7*—*Cytheridea* (*Cytheridea*) *mülleri* (Münster). *1*, Hinge of left valve. *2*, Hinge of right valve. *7*, Lateral view, right valve. (p. 699)

3, *4*, *9*—*Cytheridea* (*Haplocytheridea*) *montgomeryensis* Howe and Chambers. *3*, Hinge of left valve. *4*, Hinge of right valve. *9*, Right valve view. (p. 700)

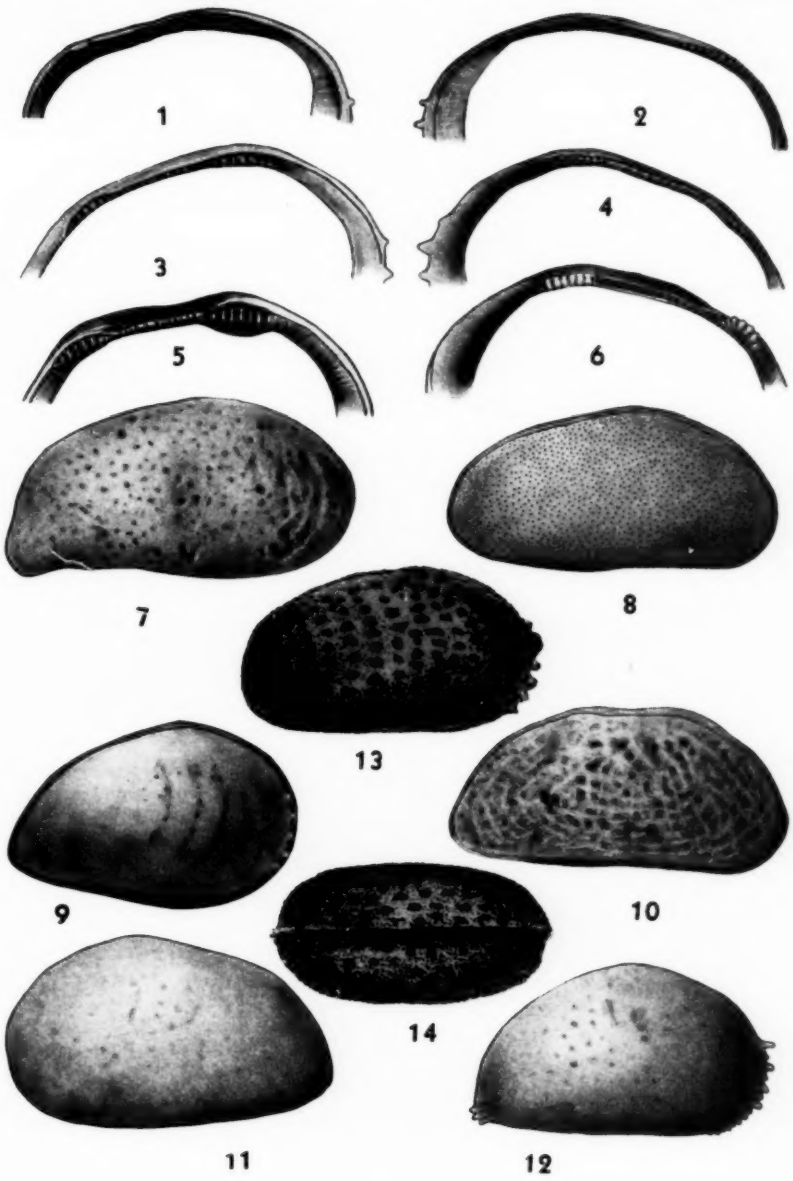
5, *6*, *10*—*Cytheridea* (*Clithrocytheridea*) *garretti* Howe and Chambers. *5*, Hinge of left valve. *6*, Hinge of right valve. *10*, Right valve view. (p. 702)

8—*Cytheridea* (*Clithrocytheridea*) *grigsbyi* Howe and Chambers var. *vicksburgensis* Stephenson, n. var., right valve view. (p. 703)

11, *12*—*Cytheridea* (*Haplocytheridea*) *blanpiedi* Stephenson, n. sp. *11*, Lateral view, left valve. *12*, Lateral view, right valve. (p. 701)

13, *14*—The first drawings of *Cytheridea mülleri* (from Roemer, 1838). (p. 695)

All figures ×55, except 13, 14.



Stephenson, Tertiary Ostracodes

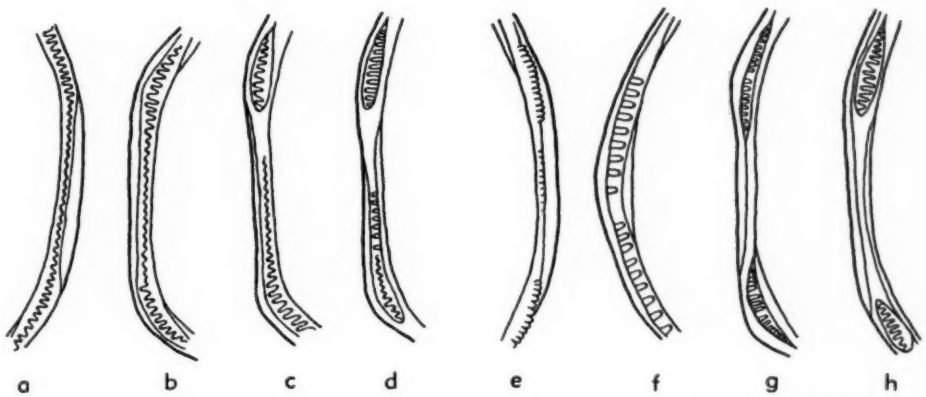
UNIV. OF MICH.

Bull. 5, pp. 17, 18, pl. 1, fig. 1; pl. 2, figs. 1–3, 7, 9; pl. 6, figs. 17, 18.

Carapace tumid, in side view subpyriform, highest just anterior to the middle. Dorsal margin gently arched, ventral margin straight. Anterior end broadly rounded and bearing about six short spines; posterior end acute, with fewer spines. Left valve larger than the right, with the greatest overlap on the dorsal and ventral sides. Exterior smooth, finely and evenly punctate, with normal pore-canals showing over the entire surface. A distinct vertical sulcus is present on many specimens. Hinge in the right valve consists of slender terminal dental areas, faintly notched to form about five teeth, connected by a narrow, projecting line of crenulations set off from the dorsal margin by a faintly incised line. In the left valve, hinge with corresponding notched sockets, connected by a crenulate groove which is terminated dorsally by the slightly raised dorsal margin. The line of concrescence coincides with the inner margin except on the anterior and posterior, where it is slightly removed. Radial pore-canals simple, mostly unbranched, about thirty-five in number on the anterior, with about half that number on the posterior. Six muscle scars are present, four in a vertical row slightly anterior to the middle, with two larger, obliquely elongate scars anterior to them, one on a level with the uppermost scar in the row, the other below it and somewhat ventral to the lowermost scar in the vertical row.

Length, 0.75 mm.; height, 0.46 mm.; width, 0.35 mm. (complete specimen).

The hypotypes, Nos. 1413, 1414, 1415, 1416, H. V. Howe collection, are from the basal Jackson Eocene, Loc. 1.



Text-figure 2.—Hinge structure of several European species of *Cytheridea* (after Zalányi, 1913). a, *Cytheridea gigantea* Zalányi; b, *C. krenneri* Zalányi; c, *C. perforata* Roemer; d, *C. entzi* Zalányi; e, *C. punctillata* Brady var. *sarmatica* Zalányi; f, *C. dérii* Zalányi; g, *C. torosa* (Jones) var. *lenta* Zalányi; h, *C. rubra* G. W. Müller var. *sera* Zalányi.

CYTHERIDEA (HAPLOCYTHERIDEA) BLANPIEDI Stephenson, n. sp.

Plate 94, figures 11, 12; Text-figures 1*e*, *f*, *m*, *n*

Carapace tumid, in side view subpyriform, highest and thickest slightly anterior to the middle. Dorsal margin well arched, flattened along the hinge line; ventral margin straight. Anterior broadly rounded, showing a number of fine, blunt spines; posterior obliquely truncated and roundly pointed, bearing a few similar spines. Left valve larger and less angular than the right. Surface fairly smooth, covered with large, regularly and closely spaced pits. Many specimens show a short, sharply defined, vertical median sulcus in the dorsal half of the carapace. Hinge in the right valve with strongly

notched dental areas connected by a low line of crenulations. In the left valve hinge consisting of deeply notched sockets joined by a crenulate groove. Six muscle scars are present, arranged in a vertical row of four, with two oblique scars anterior to them. Marginal pore-canals very numerous on the anterior and posterior with fewer on the ventral.

Length (right valve), 0.77 mm.; height 0.41 mm.; length (left valve), 0.83 mm.; height, 0.47 mm.

The syntypes, Nos. 1425, 1426, H. V. Howe collection, are from the upper Byram Marl Oligocene, Loc. 2.

Named in honor of Mr. B. W. Blanpied, Geologist, Gulf Refining Company of Louisiana, who collected specimens at this locality.

Subgenus CLITHROCYTHERIDEA Stephenson, new subgenus

Subgenotype *Cytheridea* (?) *garretti* Howe and Chambers.

Members of this subgenus are distinct from those of the two subgenera previously discussed in the characteristics of the hinge line, a feature which deserves careful consideration. The two notched, terminal dental areas in the right valve are truncated into a crenulate connecting groove. The hinge of the left valve possesses elliptical notched sockets corresponding to the dental areas in the right valve, with an elevated, crenulate bar between the sockets. In numerous representatives of this subgenus the marginal area of the right valve bears a projecting, acute carina, parallel to and just inside the outer edge of the valve. This carina fits into a groove or lip line in the opposite valve. In *Cytheridea* (*Clithrocytheridea*) *garretti* this lip line is most prominent in the posterior half of the ventral margin.

In all other shell characteristics this subgenus is identical with the two previously described.

The range of *Clithrocytheridea*, as observed by me, is Eocene to Miocene.

CYTHERIDEA (CLITHROCYTHERIDEA) GARRETTI Howe and Chambers

Plate 94, figures 5, 6, 10; Text-figures 1 *l*, *o*, *p*

Cytheridea (?) *garretti* HOWE and CHAMBERS, *1935*, Louisiana Dept. Cons., Geol. Bull. 5, p. 14, pl. 1, figs. 4, 5; pl. 2, figs. 11, 12; pl. 6, figs. 10, 11.

Carapace in side view subpyriform, highest slightly anterior to the middle. Dorsal margin weakly arched, flattened along the hinge line; ventral margin slightly sinuated. Anterior end broadly rounded; posterior end bluntly truncate to the somewhat rounded postero-ventral angle. Surface fairly evenly covered with large, deep pits, the area between pits standing in relief as a reticulate pattern of ridges. Hinge in the right valve composed of two strongly elevated dental areas, deeply notched to form about six cusps. The terminal teeth are sharply truncated into a well-entrenched, crenulate groove between them, terminated dorsally by the lowered, rounded dorsal margin. Hinge in the left valve consists of elongate, deeply notched, terminal sockets, the anterior much more prominent than the posterior, connected by a narrow, strongly raised, crenulate bar set off from the dorsal margin by a faintly incised line. The marginal area bears a broad, deep lip line along the ventral side of the left valve, which receives a strong, ventral carinate ridge of the right valve. The line of concrescence coincides with the inner margin throughout. Marginal pore-canals numerous on the anterior and posterior, with a fewer number extending nearly the entire distance around the ventral margin. Muscle scars obscure.

Length, 0.84 mm.; height, 0.41 mm.; width, 0.38 mm.

The hypotypes, Nos. 1417, 1418, 1419, H. V. Howe collection, are from the basal Jackson Eocene, Loc. 1.

CYTHERIDEA (CLITHROCYTHERIDEA) GRIGSBYI Howe and Chambers var. VICKSBURGENSIS Stephenson, new var.

Plate 94, figure 8; Text-figures 1*c*, *d*, *i*

Variety differing from the typical most noticeably in the hinge structure. The dorsal margin is flattened and follows the hinge line rather closely, with only a slight depression separating them, the pronounced depression between the hinge and the arched dorsal margin in the typical species being absent. The distance between the terminal elements of the hinge is also much longer. The thickening of the interior of the carapace along a median line from the dorsal to ventral sides, a feature common to adult specimens of the typical species, is lacking in the variety.

Length of holotype, 0.80 mm.; height, 0.40 mm.; width, 0.38 mm.

The holotype, No. 1420, and paratypes Nos. 1421, 1422, H. V. Howe collection, are from Loc. 3, Mint Spring marl Oligocene. Hypotypes, Nos. 1423, 1424, of *C. grigsbyi*, from the Jackson Eocene, Loc. 1, were used for the comparative study.

LOCALITIES

Loc. 1. Basal Jackson Eocene, exposed on Shubuta Creek, 100 yards east of Nancy-Shubuta road bridge foundation, 3.6 miles northwest of Shubuta, Clarke County, Miss. Collected by R. B. Grigsby.

Loc. 2. Upper Byram Marl Oligocene, exposed on Murder Creek, 44 feet above the bridge east of Castleberry, Conecuh County, Ala. Collected by B. W. Blanpied.

Loc. 3. Mint Spring Marl Oligocene, Glass Bayou, Vicksburg, Mississippi. This sample is from bed 6 of the following section collected by Karl E. Young from the top of the second falls in Glass Bayou, upstream from the Mississippi River to the base of the first falls.

1. Pleistocene gravels, 2 feet.
2. Fossiliferous marl, 20 feet.
3. Massive limestone, 25 feet.
4. Yellow-gray marl, 3 feet.
5. Bluish-gray sandy clay, 7 feet.
6. Shell bed in clay, 0.7 feet.
7. Dark-gray clay with sandy streaks, 9 feet.

Loc. 4. Upper Oligocene beds exposed at Astrupp, near Osnabrück, Germany. Material from several collections in this vicinity has been examined. This is the type locality of *Cytheridea mülleri*.

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MORTON B. STEPHENSON, LOUISIANA STATE UNIVERSITY, BATON ROUGE, LA. MANUSCRIPT RECEIVED BY THE EDITOR, MARCH 30, 1936.

JOURNAL OF PALEONTOLOGY, VOL. 10, NO. 8, PP. 704–714, PL. 95, DECEMBER, 1936

CARBONIFEROUS TRILOBITE GENERA

J. MARVIN WELLER

ABSTRACT

Most Carboniferous trilobites have been referred to one or the other of Portlock's genera, *Phillipsia* and *Griffithides*, and much confusion exists because no clear distinction has ever been made between them. A comprehensive study of American Carboniferous forms indicates that several distinct generic groups are present. *Phillipsia* and *Griffithides* are emended to accommodate two of these genera, *Ditomopyge* Newell is recognized, and the new genera *Exochops*, *Paladin*, *Kaskia*, *Sevillia* and *Ameura* are proposed. Two new species, *Kaskia chesterensis* and *Sevillia sevillensis*, genotypes of their respective genera, are described.

The great majority of Carboniferous trilobites have been referred to either *Phillipsia* or *Griffithides*, genera proposed by Portlock in 1843 on the basis of Lower Carboniferous specimens collected in North Ireland. Portlock did not designate genotypes nor directly compare these genera, and the species assigned to them by him do not, in either case, appear to be entirely congeneric according to modern standards. As described by Portlock and subsequent authors these genera do not merit separate recognition. This is amply demonstrated by the confusion which exists throughout Carboniferous paleontological literature. Considerable diversity of form and detail is, however, exhibited by the Carboniferous trilobites and upon careful analysis and comparison they appear to be separable into several distinct and easily recognized groups. It is proposed that these be recognized as individual genera and by redefining *Phillipsia* and *Griffithides* on the basis of the genotypes selected by Vogdes these names may be applied to two of them.

DESCRIPTIONS

Genus PHILLIPSIA Portlock, emend. J. M. Weller

Phillipsia PORTLOCK, *1843*, Geol. Rept. Londonderry etc., p. 305.

Genotype, *Asaphus gemmuliferus* PHILLIPS, *1836* (=*P. kellii* PORTLOCK, *1843*) by subsequent designation (VOGDES, *1890*), Lower Carboniferous limestone of Yorkshire, England, and Kildare, Dublin and Tyrone, Ireland.

Cephalon with flat marginal band anterior to glabella. Glabella not expanded in front, sides nearly parallel and straight, widest posteriorly at the basal lobes. Basal furrows strongly curved. Eyes relatively small.

Thorax with nine segments.

Flange of pygidium not well defined, segmentation of pleural lobes extending nearly to margin. Axis of pygidium low, nearly uniformly arched transversely.

Range.—This genus appears to be restricted to the Lower Mississippian in North America.

Remarks.—*Phillipsia*, as restricted, is the most primitive of the genera here considered. It is believed to have been indirectly ancestral to the new genera *Ameura* and *Sevillia*, and probably also to the Permian genera *Anisopyge* and *Pseudophillipsia*. *Brachymetopus* may have been derived from *Phillipsia* or these two genera may have developed from a common ancestor.

Phillipsia differs from all of the other

genera considered here in having a nearly parallel-sided glabella.

Portlock assigned four species and an additional variety to his genus *Phillipsia* in the following order: *P. kellii* (=*Asaphus gemmuliferus* Phillips, 1836), *P. ornata* (=*Asaphus truncatula* Phillips, 1836), *P. jonesii* var. *seminiferus*? (Phillips) (=*Entomolithus* (*Onescites*) *derbiensis* Martin, 1809), and *P. maccoyi*. The heterogeneous nature of this assemblage was soon recognized and in 1847 M'Coy removed *P. maccoyi* and made it the genotype of *Brachymetopus*. Although the remaining species are all still currently referred to *Phillipsia*, *P. derbiensis* differs conspicuously from the others in the absence of a flat marginal band anterior to the glabella, the differently shaped glabella with undulatory sides and greatest width between the eyes, and the very much larger eyes; it should probably be removed and made the type of a new genus.

The inclusion of several distinct trilobite types in the genus *Phillipsia* has been largely responsible for the great confusion that has always existed in the classification of Carboniferous trilobites, most of which have been referred either to this genus or to *Griffithides*, which was also proposed by Portlock in 1843. The characters supposed to distinguish these two genera were briefly mentioned by Portlock, more clearly indicated by Woodward, listed by Vogdes, and may be tabulated as follows:

Distinguishing Features of Phillipsia *and* Griffithides

	Phillipsia	*Griffithides*
Glabella	Parallel-sided	Pyriform
Basal lobes	Joined to glabella	Distinct from glabella
Lateral furrows	Two or three, short	None
Eyes	Large, reniform	Small, lunate

In actual practice almost all authors have relied solely upon the presence or absence of lateral glabellar furrows in assigning species between these two genera. Observations of numerous specimens however, clearly show that lateral furrows are at least faintly present on almost all well-preserved specimens, and comparison of closely related or even conspecific individuals demonstrates that the strength of these furrows is somewhat variable. Therefore, generic determinations based only on these structures are unjustified and in many cases erroneous.

Recently Weber tabulated the differences between *Phillipsia* and *Griffithides* in more detail somewhat as follows:

Distinguishing Features of Phillipsia *and* Griffithides *according to Weber*

	Phillipsia	*Griffithides*
Shape of glabella	Subcyclindrical	Pyriform
Frontal part	Mostly flat	Inflated
Frontal border	Mostly projecting in front of glabella	Mostly concealed by glabella or absent
Basal furrows	Similar to but stronger than anterior furrows	Differing from anterior furrows
Basal lobes	Connected with glabella	Separated from glabella
Anterior furrows	2 or 3 pairs, clearly defined	Absent, or 1 or 2 pairs faint
Pygidial axis	12 to 23 segments	10 to 13 segments
Pygidial pleurae	12 segments	9 segments

He made no attempt, however, to redefine or restrict *Phillipsia* and apparently relied principally upon the strength of the anterior glabellar furrows in discriminating between this genus and *Griffithides*. Also he has continued to describe the forms of the glabellae as "subcylindrical" and "pyriform," re-

spectively, although he retained *P. derbiensis* in *Phillipsia* with which it does not conform in this respect.

As currently interpreted, *Phillipsia* is not a useful genus but rather an artificial assemblage of more or less diverse and not closely related trilobite types. It is only by close restriction that it can be given definite meaning and secure status. Therefore, as outlined in the definition of characters here given, it is now proposed to restrict this genus to accord with the characters of two of Portlock's original species, one of which was selected by Vogdes as the genotype.

The following described North American species appear referable to *Phillipsia* as redefined: *Proetus swallovi* Shumard, 1855; *Griffithides(?) sedaliensis* Vogdes, 1888; *Phillipsia sampsoni* Vogdes, 1888; and *Proetus placidus* Vogdes, 1896.

Genus GRIFFITHIDES Portlock emend. J. M. Weller

Griffithides PORTLOCK, *1843*, Geol. Rept. Londonderry etc., p. 310.

Genotype, *Griffithides longiceps* PORTLOCK, *1843* by subsequent designation (Vogdes 1890), Lower Carboniferous limestone of Tyrone, Ireland.

Cephalon without flat marginal band anterior to glabella. Glabella expanded in front. Basal furrows not strongly curved. Eyes comparatively small.

Thorax with nine segments.

Flange of pygidium not well defined, segmentation of pleural lobes extending faintly nearly to margin. Axis of pygidium low, nearly uniformly arched transversely. Axial segments 13 to 16; pleural segments 10 to 12.

Range.—This genus is represented in the Middle Mississippian (Valmeyer series) and the Upper Mississippian (Chester series) in North America. It probably also occurs in the Lower Mississippian (Kinderhook series).

Remarks.—Griffithides, as here restricted, probably developed in Early Mississippian time from a form resembling *Phillipsia* (restricted) but with basal furrows not so strongly curved. *Exochops* appears to have separated from *Griffithides* early in its development. So far as is known, the line of *Griffithides* became extinct in Late Mississippian time.

Griffithides may be distinguished from all other genera considered here by the following combination of characters: absence of flat anterior cephalic margin, comparatively small eyes which are covered by palpebral lobes, and lack of well-defined unsegmented pygidial flange.

Portlock assigned four species to this genus in the following order: *G. longiceps*, *G. globiceps* (Phillips, 1836), *G. platiceps* and *G. longispinus*, all of which were based on more or less incomplete specimens. Subsequent collecting has yielded additional representatives of the first two species which are now well known. The type of *G. globiceps* is a fragmental cranidium and need not be considered until more complete specimens have been found. The last species was based on a partially exfoliated, enrolled individual not all of whose characters, apparently, can be determined. Portlock did not designate a genotype for *Griffithides*, but Vogdes subsequently selected *G. longiceps* which is representative of a small group of trilobites common to Europe and America. *G. globiceps* differs from the genotype in the general configuration of its cephalon and probably also in other ways. Perhaps it should be referred to another genus. *G. longispinus* should probably be retained in the genus *Griffithides* as here restricted.

The characters by which *Griffithides* has previously been distinguished from *Phillipsia* have been considered in the discussion of that genus. It is only necessary to repeat here that the strength of the anterior glabellar furrows does not appear to be of generic significance without the support of other distinguishing characters. Like *Phillipsia*, *Griffithides* can be made into a useful genus only by restricting the use of this name to a compact group of closely related species, and many forms that have long been referred to it must be removed to other, mostly new, genera.

Described species from North America that are referred to *Griffithides* as emended include: (?) *Phillipsia meramecensis* Shumard, 1855; *Phillipsia (Griffithides) bufo* Meek and Worthen, 1870; and *Griffithides pustulosus* Snider, 1915.

Genus EXOCHOPS J. M. Weller, n. gen.

Genotype, *Phillipsia portlocki* MEEK and WORTHEN, *1865*, from the Keokuk formation (Middle Mississippian) of western Illinois.

Cephalon without flat marginal band anterior to glabella. Glabella expanded in front, narrowest between the eyes. Basal furrows not strongly curved. Eyes small, not covered by palpebral lobes.

Thorax with nine segments.

Flange of pygidium not well defined, segmentation of pleural lobes extending faintly nearly to margin. Axis well elevated, strongly arched transversely. Axial segments 14 to 15; pleural segments 10 to 11.

Range.—Known only in the Keokuk formation of Illinois, Iowa, and Missouri.

Remarks.—Exochops is believed to have evolved from *Griffithides* near the close of Early Mississippian time. It apparently did not survive the Middle Mississippian.

The migration of the eyes out from beneath the palpebral lobes serves to distinguish this genus from all others considered here.

Because *Exochops* is a monotypic genus it is not known whether the bluntly subtriangular cephalon, so different from that of *Griffithides*, is a generic or specific character.

The name is derived from ἔξοχος prominent and ὤψ eye.

Genus PALADIN J. M. Weller, n. gen.

Genotype, *Griffithides morrowensis* MATHER, *1915*, from the Morrow (lowest Pennsylvanian) of Arkansas.

Cephalon with flat marginal band anterior to glabella. Glabella expanded in front. Basal furrows not strongly curved. Eyes large.

Thorax with nine segments.

Flange of pygidium distinct, not bearing faint continuations of intersegmental pleural furrows except anteriorly. Axial segments 14 to 16; pleural segments 9 to 10.

Range.—Upper Mississippian (Chester series) to Lower Pennsylvanian (Morrow group—lower Pottsville)in Arkansas, Illinois, and Oklahoma; Moscovian and Uralian of Russia.

Remarks.—Paladin appears to have developed at a later date from the same stock that gave rise to *Griffithides*.

Its advanced type of pygidium and large eyes distinguish *Paladin* from the older genera, *Griffithides*, *Exochops* and *Phillipsia*. Its flat anterior rim serves to separate it from *Kaskia* of similar age. The absence of a preoccipital lobe differentiates this genus from the Pennsylvanian genera *Ditomopyge* and *Sevillia* and its anteriorly expanded glabella distinguishes it from *Ameura*.

Although the range of this genus, as given above, has not been extended above the basal Pennsylvanian of the states mentioned, a single cranidium tentatively referred to it has been collected from beds considerably higher in this system. This specimen is of small size and is incomplete, and because of its imperfections and the possibility that it may not have reached mature development, its identification is uncertain. This specimen, however, strongly suggests that *Paladin* may range well up in the Pennsylvanian system.

The Russian species *Griffithides lutugini* Weber, *G. cervilatus* Weber, and *G. transilis* Weber appear to be typical representatives of *Paladin*. They occur in the Moscovian (Pennsylvanian) and Uralian (=our Lower Permian) thus extending its range much beyond that which is known in America.

Described species from North America that are referred to *Paladin* include: *Proetus granulatus* Wetherby, 1881; *Griffithides mucronatus* Girty, 1910; and *Griffithides morrowensis* Mather, 1915.

The name of this genus is derived from a title for legendary peers of Charlemagne, signifying knight errant.

Genus KASKIA J. M. Weller, n. gen.

Genotype, *Kaskia chesterensis* S. Weller and J. M. Weller, n. sp., from the Upper Mississippian (Chester series) of Illinois, Kentucky and Oklahoma.

Cephalon with flat marginal band anterior to glabella absent or nearly obsolete in mature specimens. Glabella expanded in front. Basal furrows not strongly curved. Preoccipital lobe absent. Eyes large.

Thorax with nine segments.

Flange of pygidium well defined, not bearing faint continuations of intersegmental pleural furrows except anteriorly. Axis elevated, subtrapezoidal in cross section, crest gently arched transversely. Axial segments 13 to 17; pleural segments 8 to 12.

Range.—Meramec group of the Middle Mississippian in Indiana (Salem limestone) and Iowa (Pella beds); Upper Mississippian of Illinois, Kentucky and Oklahoma; Moscovian and Uralian of Russia.

Remarks.—The very close similarity of this genus to *Paladin* suggests that both were derived from a common ancestor, rather than that *Kaskia* was descended from *Griffithides* which it superficially resembles. *Kaskia* appears to have become extinct in the Western Hemisphere at the close of Mississippian time, but it is probable that this genus early gave rise to *Ditomopyge* which persisted into the Permian.

The absence or near absence of a flat marginal band anterior to the glabella distinguishes *Kaskia* from all others considered in this work except *Griffithides*, *Exochops* and *Ditomopyge*. The more advanced type of pygidium and larger eyes differentiates it from *Griffithides*, and the covering of the eyes by the palpebral lobes in addition to these same characters separates it from *Exochops*. *Kaskia* differs from *Ditomopyge* by the absence of a preoccipital lobe.

Not all individuals belonging to this genus are so clearly distinguishable from the closely related genera *Paladin* and *Ditomopyge* as the above statements of differences might indicate. Immature cranidia of *Kaskia* commonly possess a well defined but narrow flat marginal band anterior to the glabella and a faint trace of this structure is retained in some fully adult American specimens. On the other hand, some specimens from the middle and upper Chester formations possess more or less indistinct suggestions of a preoccipital lobe. In spite of these facts, however, the general development of *Kaskia* is quite distinctive.

The Russian forms *Griffithides transilis* varieties *A* and *B* Weber and *G. ovoides* Weber appear to be typical representatives of *Kaskia*. Others such as *G. lutugini* var. *robusta* Weber and *G. transilis* Weber are more or less intermediate between this genus and *Paladin*. Although the Russian trilobites seem to belong to the same genera as the American species, their associations and ranges are peculiar. *Kaskia* and *Paladin*, which characterize the Upper Mississippian here, are unknown below the Moscovian (Pennsylvanian) in the Donetz Basin where they accompany *Ditomopyge* and range far beyond their last known American occurrence.

Described species from North America that are referred to *Kaskia* include: (?) *Phillipsia stevensoni* Meek, 1871; *Griffithides wilsoni* Walter and *G. wilsoni* var. *genevievensis* Walter, 1927; and (?) *Proetus bairdensis* Wheeler, 1935.

The name of the genus is a contraction of Kaskaskia, a term formerly applied to the Chester series in which this genus predominates.

KASKIA CHESTERENSIS S. Weller and J. M. Weller, n. sp.

Plate 95, figures 4*a*–6

The material in hand includes 7 complete enrolled specimens, 2 cephalons, 25 cranidia, 5 free cheeks, and 83 pygidia, from 42 localities.

Cephalon broadly rounded in front, ratio of breadth to length about 1.4 to 1.5; genal spines long, acute, extending nearly the whole length of the thorax. Glabella inflated, uniformly arched longi-

tudinally, ratio of length to breadth about 1.1 to 1.3. Neck-ring wide; occipital furrow shallow, very narrow, narrowly rounded to angular, curved strongly forward in middle. Basal lobes moderately large, not elevated; basal furrows originating at or a little before middle of palpebral lobes, slightly curved, fairly well impressed in the middle but shallow and broad in front and in some specimens nearly obsolete behind. Anterior furrows in two pairs very short and faint, obsolete in some specimens. Fixed cheeks narrow in front of palpebral lobes, considerably wider anteriorly; palpebral lobes twice or more than twice as long as wide, one-third or a little less than one-third as long as glabella, raised very little above axial furrows. Cephalic pores small. Eyes twice as wide as long, about half as long as glabella. Base of eye defined by sharp but faint groove, cornea smooth. A shallow rounded, narrow furrow parallels base of eye on side, becoming obsolete before and behind, not bounded below by ridge. Lateral slope of cheek of moderate width, very steep below eye, separated from posterior slope by broad, low, rounded ridge. Lateral rim of cheek convex, separated from lateral cheek slope by abrupt change in inclination; upper surface sloping gently outward and rounding into outer surface which becomes nearly vertical below. Furrow bounding posterior rim of cheek angular, rather shallow and open. Center of neck-ring bears low, rounded node, entire surface granulose with some larger granules along posterior edge. Basal and palpebral lobes and main part of glabella granulose, ornamentation coarsest on basal lobes and posterior part of glabella, becoming gradually finer forward and nearly disappearing on anterior part. A few fine granules occur below rounded furrow paralleling base of eye and on crest of ridge separating lateral and posterior slopes of cheek; remainder of cheek smooth except for minute irregularly distributed pits.

Pygidium generally broadly rounded behind, ratio of breadth to length about 1.1+ to 1.4−. Axis composed of 14 to 17 segments, more than one-third as wide as pygidium anteriorly, decreasing slightly in elevation posteriorly, narrowing behind to blunt, rounded, slightly elevated termination. Crest of axis elevated, well arched transversely, narrowing behind; furrows moderately impressed, narrow, rather angular. Sides of axis flat to gently concave, sloping somewhat more steeply behind; furrows shallow in front, becoming obsolete behind. Pleural lobes nearly horizontal above, rounded rather sharply downward at about mid-width, composed of about 10 to 12 segments separated by shallow angular furrows. Subsidiary furrows present very faintly on first one to three pairs of pleura or entirely obsolete. Flange of pygidium gently convex or flat, continues slope of segmented pleural lobes or is slightly less inclined. Crest of pygidial and thoracic axis ornamented with rows of granules on posterior edges of segments, rather obscure on some specimens; first few thoracic segments appear to bear small granules over the whole surface of crest. Pleura smooth or very finely granulose in some specimens. Flange smooth or marked by irregular, discontinuous, concentric lyrae.

Occurrence.—Throughout the Chester series in southern Illinois and western Kentucky; Pitkin and Mayes formations (Chester) in northeastern Oklahoma; "Maxville" limestone, Pennsylvania.

Types.—Holotype, Walker Mus. (Univ. Chicago) No. 34437; paratype, No. 25165.

Remarks.—This species was described as new by Prof. Stuart Weller under the name *Phillipsia okawensis* in an unfinished manuscript on the fauna of the Camp Creek bed of the Okaw limestone in Randolph County, Illinois. In another unfinished manuscript on the fauna of the Marigold oolite member of the Okaw limestone in the same county he referred similar specimens to *Phillipsia granulata* (Wetherby). The examination of a considerable number of Chester specimens from different horizons and widely sepa-

rated localities has revealed the difficulties that would be encountered in an attempt to subdivide them into two or more species. Considerable variation is present between specimens in single collections; other variations appear to bear some relation to stratigraphic position (for example the glabellar ratio of Renault specimens is about 1.1; Golconda and Glen Dean specimens about 1.2; and Menard specimens about 1.3). It is possible that more excellent material would allow the recognition of two or more species but at present it seems advisable to group these specimens into a single species, realizing, however, that certain progressive variations occur from horizon to horizon. Because Professor Weller's types of *P. okawensis* are incomplete specimens and because the species as here conceived is of widespread occurrence throughout the Chester series, both his types and name have been discarded and in their places a more complete specimen and a more general name have been selected.

Although this species is referred to the genus *Kaskia*, the glabellae of several mature specimens that have been examined do not reach entirely to the forward margin of the cephalon. In most of these specimens there is no flat anterior border, and the striated margin simply continues the forward convex slope of the glabella, but in a few there is a distinct suggestion of a flattened border, and immature specimens retain a fairly conspicuous development of this feature which is here considered to be characteristic of the genus *Paladin*. Such variations are confusing, but they appear to prove the ancestral derivation of *Kaskia* from a form possessing a flat anterior margin. It is also interesting that certain glabellae are slightly constricted between the basal lobes and furnish a forecast of the preoccipital lobe that characterizes the Pennsylvanian genus *Ditomopyge*.

The cephalon of this species can possibly be distinguished from *K. wilsoni* (Walter) by its less angulated cheek rims and basal furrows which are deeply impressed in the middle but nearly obsolete near the occipital furrow. The pygidia of this species are relatively more narrow, have narrower and more elevated axes, and a greater number of segments.

This species differs from *Griffithides pustulosus* Snider in its larger eyes and palpebral lobes, the much narrower, rounded furrows below the eyes, smaller basal lobes, more curved occipital furrow, finer glabellar ornamentation, and nonundulating pygidial flange. It may be separated from *Paladin mucronatus* (Girty) by the absence of a flattened band anterior to the glabella, smaller eyes, sharper and narrower occipital furrow, wider pygidial axis, and greater number of pygidial pleurae.

The name *K. chesterensis* may prove to be a synonym of *Phillipsia stevensoni* Meek, described from the Chester series of West Virginia. It is likewise possible that this name is synonymous with

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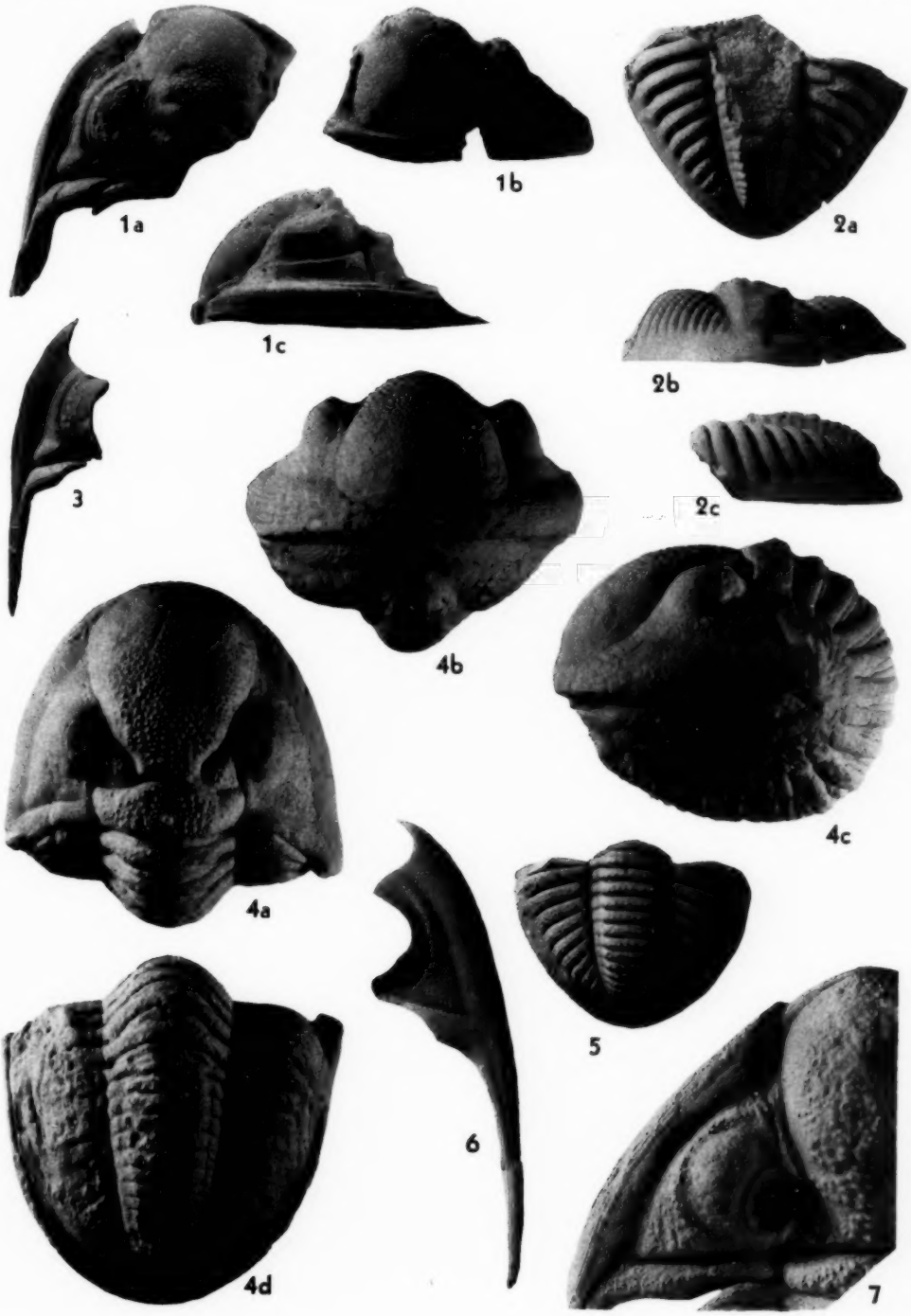
EXPLANATION OF PLATE 95

FIGS. *1a–3—Sevillia sevillensis* J. M. Weller, n. sp. *1a–c*, Holotype, ×4; Seville limestone, SW. ¼ NE. ¼ sec. 25, T. 6 N., R. 1 E., Fulton County, Ill. (Ill. Geol. Survey Coll. no. 2172). *2a–c*, Associated pygidium, ×4; same horizon, locality and number. *3*, Free cheek, ×2; Seville limestone, NE. ¼ sec. 13, T. 17 N., R. 1 W., Rock Island County, Ill. (Ill. Geol. Survey Coll. no. 2255). (p. 712)

4a–6—Kaskia chesterensis S. Weller and J. M. Weller, n. sp. *4a–d*, Holotype, ×4; Shetlerville member of Renault formation, 4 miles west of Marion, Crittenden County, Ky. (Walker Mus., Univ. Chicago, no. 34437). *5*, Pygidium, ×4; Glen Dean limestone, 2½ miles southeast of Vienna, Johnson County, Ill. (Walker Mus., Univ. Chicago, no. 30419). *6*, Free cheek, ×4; Marigold member of lower Okaw limestone, 1½ miles south of Marigold, Randolph County, Ill. (Walker Mus., Univ. Chicago, no. 25165). (p. 708)

7—Exochops portlocki (Meek and Worthen). Holotype, ×4. Keokuk (or Warsaw?) formation, Warsaw, Hancock County, Ill. (Univ. Illinois, Worthen Coll.). (p. 707)



Weller, Carboniferous Trilobites

UNIV. OF MICH.

Proetus granulatus Wetherby from the Chester of eastern Kentucky. Neither of these earlier species, however, has been adequately described or illustrated and the types cannot be located.

Two pygidia labeled *Phillipsia stevensoni* presented to Walker Museum by Prof. J. J. Stevenson, presumably collected and identified by him, have been referred to *K. chesterensis* because they possess no characters that serve to distinguish them from the southern Illinois and western Kentucky specimens for which this latter name is proposed.

Genus DITOMOPYGE Newell, emend. J. M. Weller

Ditomopyge NEWELL, *1931*, Jour. Paleontology, vol. 5, p. 268.—WELLER, *1935*, Jour. Paleontology, vol. 9, p. 505.
Cyphinium WEBER, *1933*, United Geol. Prosp. Service U.S.S.R., Trans., fasc. 255, p. 81.
Genotype, *Ditomopyge lansingensis* Newell, 1931, Plattsburg limestone (Middle Pennsylvanian), Kansas.

Cephalon without flat marginal band anterior to glabella. Glabella expanded in front. Basal furrows not strongly curved. Preoccipital lobe present. Preoccipital furrow straight, transverse. Eyes relatively large.

Thorax with nine segments.

Flange of pygidium well defined, not bearing faint continuations of pleural intersegmental furrows except anteriorly. Axis elevated, crest commonly flattened, trapezoidal in cross section. Axial segments 11 to 15; pleural segments 7 to 9.

Range.—Throughout the Pennsylvanian and Lower Permian in North America; Upper Carboniferous of Russia.

Remarks.—The foreshadowing of the development of a preoccipital lobe in the later representatives of the genus *Kaskia* suggests that that Mississippian genus evolved slowly and directly into Pennsylvanian *Ditomopyge*. The fact, however, that *Ditomopyge* possesses a distinctly smaller number of axial segments in the pygidium than Upper Mississippian *Kaskia* appears to obviate this possibility as there is a general tendency toward greater pygidial segmentation from lower to higher horizons. Therefore, it seems probable that *Ditomopyge* was descended from Middle Mississippian *Kaskia* through a series of forms that are not yet known.

Ditomopyge may be distinguished from all other genera considered in this work by the presence of a preoccipital lobe and the absence of a flat marginal band anterior to the glabella.

This genus was established on immature pygidia possessing two posterior spines that are not present on maturely developed individuals. The discovery of a complete developmental series has established the relations of such small spined pygidia to the most abundant type of Pennsylvanian trilobite, and pygidia in a similar adolescent stage are now known in three species (Weller, 1935).

The trilobites here referred to *Ditomopyge* have been cited almost universally as species of *Griffithides*.

The genotype of *Cyphinium* Weber is *Phillipsia scitula* Meek and Worthen from the Middle Pennsylvanian of Illinois, which is very closely related to *D. lansingensis*. It is certain, therefore, that *Cyphinium* is an exact synonym of *Ditomopyge*.

Described species from North America that belong to *Ditomopyge* include; *Phillipsia cliftonensis* Shumard, 1858; *Phillipsia* (*Griffithides*) *scitula* Meek and Worthen, 1865; *Griffithides parvulus* Girty, 1911; *Ditomopyge lansingensis* Newell, 1931; *Griffithides olsoni* Williams, 1933; *Griffithides conwayensis* Wheeler, 1935 (=*G. ornatus* Vogdes, 1895).

Genus SEVILLIA J. M. Weller, n. gen.

Genotype, *Sevillia sevillensis* J. M. Weller, n. sp., from the Lower Pennsylvanian of Illinois.

Cephalon broad, blunt, with narrow flat marginal band anterior to glabella. Glabella expanded in front. Basal furrows strongly curved. Glabella inflated on either side between the lateral glabellar furrows. Preoccipital lobe present. Preoccipital furrow curved. Eyes relatively large.

Thorax probably with nine segments. Pygidium more or less narrowly rounded behind. Flange well defined, not bearing faint continuations of the pleural segments except anteriorly. Axis elevated, sides flattened, crest gently arched transversely. Axial segments 17 to 18; pleural segments 9 to 11.

Range.—Lower Pennsylvanian (Pottsville and Allegheny) in Illinois and Ohio.

Remarks.—The genetic relationship of *Sevillia* to other Carboniferous trilobite genera is uncertain but it seems most likely that it was descended from the line of *Phillipsia* (restricted). Intermediate stages which should occur in Middle and Upper Mississippian beds, if this theory is correct, are unknown in America, however, and it appears that *Sevillia* and *Ameura*, which resemble each other in several more or less significant features, migrating from some distant part of the world, first reached America in Early Pennsylvanian time.

Sevillia differs from all other genera considered here except *Ditomopyge* in the possession of a preoccipital lobe. It may be distinguished from *Ditomopyge* by the presence of a narrow but distinct flat marginal band anterior to the glabella, its curved preoccipital furrow, the inflation of the glabella on either side between the lateral glabellar furrows, and the broad blunt form of the cephalon.

The occurrence of a preoccipital lobe in both *Sevillia* and *Ditomopyge*, which are believed to be only remotely related to each other, appears to be an excellent example of the development of similar structures in different evolutionary lines at about the same time.

Phillipsia trinucleata Herrick, 1887, is the only previously described species that is referred to *Sevillia*.

The genus is named from the village of Seville, Fulton County Illinois, near which the type specimens were obtained.

SEVILLIA SEVILLENSIS J. M. Weller, n. sp.

Plate 95, figures 1*a*–3

The material on which description of this species is based includes 1 incomplete cephalon, 1 cranidium, 2 free cheeks, 5 incomplete pygidia, from 5 localities.

Cephalon broadly and evenly rounded in front, ratio of breadth to length about 1.8 to 1.9; genal spines rather slender, acute, about two-thirds as long as cephalon. Glabella strongly inflated, uniformly arched longitudinally. Marginal band anterior to glabella very narrow but distinct, flattened. Neck-ring not preserved, probably moderately wide; occipital furrow deep and probably wide. Basal lobes large, inflated; basal furrows narrow, deep, angular, originating a little behind the middle of the palpebral lobes, stongly curved. Preoccipital lobe approximately equal in size to basal lobes, its crest located in advance of the crests of the basal lobes, strongly inflated, as high or higher than the main part of the glabella, rising steeply above occipital furrow behind; preoccipital furrow broad, shallow, curved. Anterior furrows in three pairs, broad, very shallow, the last extending about one-fourth of the way across glabella, the others progressively shorter. Fixed cheeks narrow, palpebral lobes about twice as long as wide, about half as long as glabella. Cephalic pores distinct. Eyes slightly less than twice as long as wide, a little more than half as long as glabella. Surface of cornea shows faint traces of underlying lens structure. Base of eye defined by shallow but distinct groove. A low, broad, rounded ridge parallels base of eye, bounded below by well impressed rounded furrow and strong rounded ridge at top of lateral slope of cheek. Lateral slope of cheek fairly narrow, very steep, separated from posterior slope by strong, broadly rounded, diagonal ridge descending uniformly toward genal angle. Lateral rim of cheek very narrowly rounded, bounded on inside by abrupt change in inclination of surface; upper surface wide, flat or slightly concave, sloping gently outward, twice as wide as lateral slope of cheek except near genal angle where its width is reduced to half by the extension of the above mentioned diagonal ridge; outer surface gently con-

cave, inclined steeply outward. Posterior rim of cheek moderately elevated, bounded by deep, moderately narrow, angular furrow that curves backward at the genal angle and continues as shallow angular trough on upper, outward sloping surface of genal spine. Ornamentation of neck-ring unknown. Posterior and central part of glabella, including basal and preoccipital lobes, strongly granulose; furrows, except preoccipital furrow, smooth; foward and lateral parts of glabella smooth to delicately pitted. Free cheeks unornamented but finely pitted.

Pygidium subtriangular, sides nearly straight, converging, narrowly rounded behind, ratio of breadth to length about 1.3. Axis with about 17 or 18 segments about one-third as wide as pygidium anteriorly, strongly elevated in front, lower behind, tapering to a blunt well elevated or slightly overhanging termination. Crest of axis broad, moderately arched with narrow furrows, deep, angular, straight. Sides of axis flattened or slightly concave, steep, becoming steeper behind, with angular furrows, shallow in front, obsolete behind. Pleural lobes with 10 or 11 distinct, strongly convex segments separated by sharp angular furrows, the first three or four of which cross the axial furrow to connect with the intersegmental furrows of the axis. Upper surface rises gently above axial furrow then curves strongly but rather uniformly downward. Flange of pygidium slopes a little more gently than the outer parts of the segmented pleural lobes in front and is partly crossed by very shallow continuations of the first three or four intersegmental furrows, becomes conspicuously convex and a little wider behind. Crest of axis ornamented by small but distinct granules disposed principally in a row upon each segment. Pleurae marked by irregularly sized and arranged granules most conspicuously developed on highest parts. Outer border of flange carries somewhat irregular, very closely spaced sharp lyrae and central part of convex posterior portion may bear similar but more widely spaced and more irregular and discontinuous lyrae.

Occurrence.—This species is known only from the Seville limestone (caprock of Coal No. 1) in western Illinois, principally in Fulton County.

Types.—Holotype and paratype, Ill. Geol. Survey Coll. No. 2172.

Remarks.—The species differs from *S. trinucleata* (Herrick) by its larger preoccipital lobe whose crest is located in advance of the crests of the basal lobes, the probably much more granular ornamentation of the glabella, and its subtriangular pygidium with wider axial lobe and granular ornamentation. The free cheeks of this species closely resemble those belonging to the genus *Ameura* but are somewhat more slender with longer genal spines, much more distinct furrows below the eyes, sharper differentiation of rim and lateral slope and flat or concave rather than convex upper rim surface.

Genus AMEURA J. M. Weller, n. gen.

Genotype, *Phillipsia sangamonensis* MEEK and WORTHEN, *1865* (=*P. missouriensis* SHUMARD, *1858*) from the Lower and Middle Pennsylvanian of Illinois.

Cephalon broad, blunt, with flat marginal band anterior to glabella. Glabella slightly expanded in front but much the widest between the eyes. Basal furrows strongly curved. Basal lobes not inflated. Eyes large.

Thorax with nine segments.

Pygidium nearly equal in length and breadth, narrowly rounded behind. Flange well defined, not bearing faint continuations of intersegmental furrows except anteriorly. Axis comparatively narrow, strongly elevated, sides flattened, crest arched transversely, intersegmental furrows shallow, convex forward. Axial segments 16 to 25; pleural segments 9 to 14.

Ornamentation absent.

Range.—Throughout the Pennsylvanian and in the Lower Permian beds of North America.

Remarks.—There are no Mississippian

trilobites in the central North American province from which *Ameura* might have been derived and, therefore, its genetic relationship to other Carboniferous genera is dubious. It apparently migrated into the interior of North America from some foreign source early in Pennsylvanian time. The European form *Phillipsia eichwaldi* (Fischer) is suggestive of *Ameura* in several respects and may be an indirect representative of the intermediate line between this genus and *Phillipsia* (restricted), from which *Ameura* is believed to have ultimately sprung. It is probable that this genus and *Sevillia* share in some degree the same ancestry because they resemble each other in having strongly curved basal furrows and eyes whose surfaces are only slightly convex transversely, as well as possessing the probably less significant similarities of broad and blunt cephalons and posteriorly narrowly rounded pygidia.

Ameura differs from all of the other genera under consideration in the form of its glabella which is much the widest between the eyes. It is also the only Carboniferous genus which appears to be totally devoid of ornamentation.

Although the two common species of this genus, *A. sangamonensis* and *A. major* have always been referred to *Phillipsia*, they differ in almost all respects from that genus as here restricted and constitute a very distinct and easily recognized group of trilobites of definitely restricted geologic range.

Described species from North America that are referred to *Ameura* include: *Phillipsia major* Shumard, 1858 (=*Proetus longicaudus* Hall 1861, =*Phillipsia nodocostata* Hare, 1891); *Phillipsia sangamonensis* Meek and Worthen, 1865 (=*Phillipsia missouriensis* Shumard, 1858).

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JOURNAL OF PALEONTOLOGY, VOL. 10, NO. 8, PP. 715–738, PLS. 96–99, TEXT-FIGS. 1–4, DECEMBER, 1936.

THE CASPER FORMATION (PENNSYLVANIAN) OF WYOMING AND ITS CEPHALOPOD FAUNA

A. K. MILLER and H. D. THOMAS

ABSTRACT

The general nature of the Casper formation of southeastern Wyoming is discussed in this paper, an attempt is made to explain its relationships to other Late Paleozoic formations of the same and near-by regions, and much of its fauna is illustrated and described in detail. The fossils treated systematically represent one species of fusulinids, nine species of cephalopods (all nautiloids), and one species of trilobites. It is concluded that the formation probably represents the major portion of the Pennsylvanian period.

Long ago Hayden (1872) and Hague (1877) reported the occurrence of Carboniferous fossils in some of the sedimentary rocks of the Laramie Range in southeastern Wyoming. Darton (1908) described the strata which crop out on Casper Mountain (fig. 1) and in the hogbacks along the flanks of the Laramie Mountains, and listed Late Paleozoic fossils from many localities. The only Carboniferous cephalopods he obtained came from Gilmore Canyon, about 8 miles southeast of Laramie, Wyoming, and these were identified by Girty (Darton, 1908) merely as *Tainoceras occidentale*, *Nautilus* sp., *Orthoceras* sp., and "Ammonoid indet."

In 1933, while trying in vain to determine just where Darton obtained his specimens, we located in beds of slightly different lithology what is probably the same abundant cephalopod fauna, and intermittently we have been collecting from it ever since. This fauna merits consideration both because of the rarity of cephalopods in the Late Paleozoic rocks of Wyoming and because of the evidence it affords in regard to the age of the Casper formation in which it occurs. The cephalopods, and a few other significant fossils, are described below and the beds which yielded them are discussed at some length with an attempt to explain their relationships to the other Late Paleozoic strata of southeastern Wyoming and adjacent portions of Colorado. A description of the brachiopods, which are abundant in certain portions of the Casper, is, however, left for the future.

The Geological Survey of Wyoming helped to finance the field work on which this report is based, and we wish to express our sincere appreciation to Dr. S. H. Knight, State Geologist, for this assistance. Acknowledgment is also due to Prof. C. O. Dunbar, who helped us greatly with identification of the brachiopods listed below; Dr. M. L. Thompson and Dr. M. K. Elias, who studied the fusulinids we obtained; Dr. J. Marvin Weller, who advised us in regard to the significance of our

trilobites; Dr. N. D. Newell, who compared certain of our cephalopods with specimens in the collections of the Kansas Geological Survey; and several students at the University of Wyoming who aided in the collecting of specimens. Essentially all of the field and stratigraphic work was done by Thomas and the descriptions and illustrations of the fossils were prepared largely by Miller.

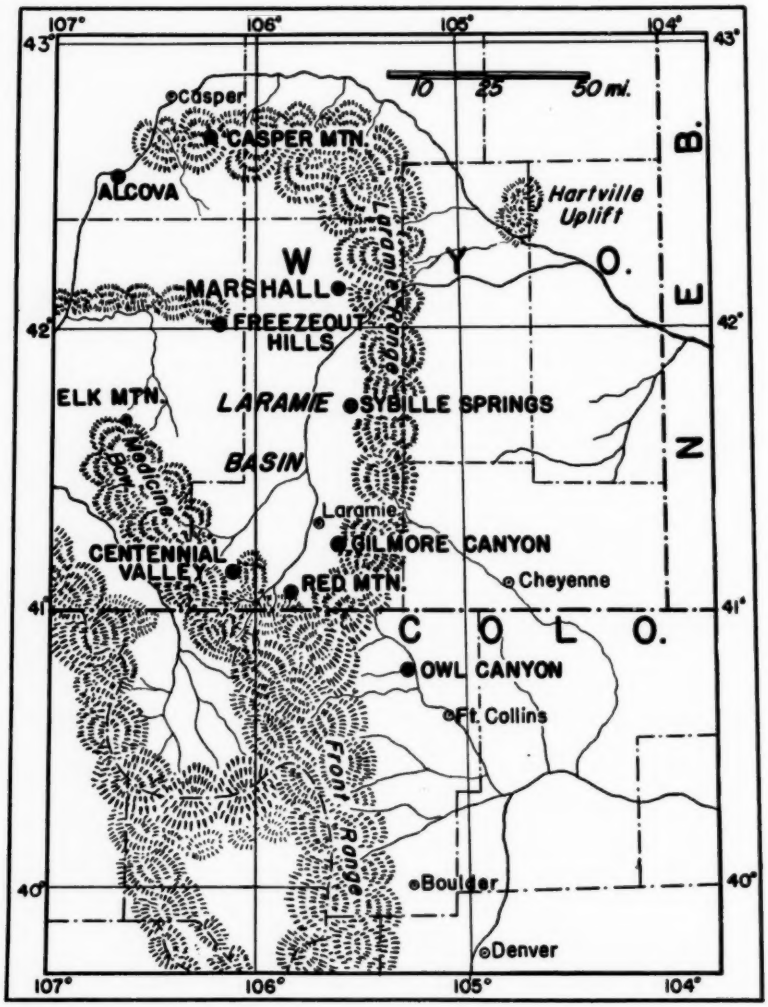

FIG. 1—Index map of southeastern Wyoming and north-central Colorado, showing localities mentioned in the text.

NOMENCLATURE OF CERTAIN LATE PALEOZOIC FORMATIONS IN THE LARAMIE BASIN

The name Casper formation was applied by Darton (1908) to a se-

quence of Carboniferous rocks which crop out along the Laramie Mountains. In the type region, around Casper Mountain, the lower part of the sequence is of Mississippian age and is now generally eliminated from the Casper. Later, Darton and Siebenthal (1909) published a detailed discussion of the lithology of the Casper beds of the Laramie Basin, and they pointed out that in the southern part of the basin the lower part of the formation consists of arkose grits, which directly overlie pre-Cambrian granite. Lee (1927) recognized that these arkoses are a northward extension of the Fountain formation of Colorado, and he carried the name Fountain into the Laramie Basin. Previously, Butters (1913) had applied the name Ingleside to the alternating sandstones and limestones which in Colorado overlie the Fountain and underlie the Lykins red-beds. Lee (1927) suggested that this name also be carried into the Laramie Basin and applied to the portion of Darton's Casper "formation" which overlies the Fountain, advocating that the name Casper be abandoned. Two years later Knight (1929) discussed in detail the distribution, lithology, and lithogenesis of the Fountain and the Casper formations in the Laramie Basin, and suggested that the name Casper be retained but used in a restricted sense, that is, to refer to the beds which overlie the Fountain arkose.

Because of the striking changes in lithology of the Casper from place to place, and because of the complex nature of the intertonguing of the beds of different lithologies, it seems to us that it is impossible without a great deal of additional detailed stratigraphic knowledge to devise a satisfactory nomenclature for the beds in the Laramie Basin which were called Casper by Darton. For the present, therefore, it will perhaps be best in areas where the Fountain is present, as in the southern part of the Laramie Basin, to use the term Casper in Knight's restricted sense. However, in the northern part of the Basin, where the Fountain beds seem to be replaced by others of different lithology, there is no name to use except Casper in Darton's sense, excluding, of course, the Mississippian strata which in some places occur between the Casper and the pre-Cambrian granite. It does not seem advisable or practical to use the term Ingleside in the Laramie Basin because the Casper at most localities, as at Sybille Springs, although lithologically similar to the typical Ingleside, represents a very much greater time interval than does the type section of that formation in Colorado. The erection of a satisfactory nomenclature for the beds now called Casper will probably have to be postponed until the time when we understand better their stratigraphic relations to the Tensleep and Amsden of central Wyoming, the Hartville of eastern Wyoming, and the Fountain and Ingleside of northern Colorado.

STRATIGRAPHY

The Casper in a broad sense rep-

resents a complex phase of intertonguing of three distinct facies: a continental arkose facies (Fountain), a cross-laminated sandstone facies (Tensleep), and a marine limestone facies. At different localities these three facies appear in varying degrees of prominence. This feature, coupled with the cyclical nature of the sedimentation and with lateral gradations in lithology, causes nearby sections of the formation to be strikingly different and makes their correlation very difficult.

In Gilmore Canyon (fig. 1) the Casper consists of about 700 feet of alternating arkose grits, festooned cross-laminated sandstones, and fossiliferous limestones. The sequence rests upon pre-Cambrian granite and is overlain by red Satanka shale of Permian age. Darton and Siebenthal (1909) measured a section of the Casper along this canyon, but their reported thickness of 1,259 feet is almost twice that of our thickness of 700 feet. It is possible that a zone of normal faulting was overlooked by them and part of the formation duplicated in measurement.

We measured detailed sections of the Casper at several points along Gilmore Canyon and traced key-beds from one section to the next. The top and bottom of the formation are exposed about 6 miles apart, and within this distance there are striking changes in the thicknesses of many of the beds, principally because the formation consists of sequences of sets of beds, cyclothems, separated by erosion surfaces which thin or completely cut away beds in the subjacent cyclothems. In general, thinning of the beds in one cyclothem seems to be compensated for by corresponding thickening of the basal unit of the superjacent cyclothem. Because of these lateral variations, the section given below is of necessity quite generalized.

Table I.—Generalized section of Casper formation, compiled from sections measured between mouth of Gilmore Canyon and a point about 1 mile south of Crow Creek Hill bench-mark, Laramie-Sherman quadrangles, Albany County, Wyoming.

	Thickness in feet
Satanka shale (Permian)	
Red shale with one thin but prominent ripple-marked sandstone in lower part	250?
Casper formation (Pennsylvanian)	
Alternating thin sandstones and siltstones, red and buff in color	9
Derbya beds. Thin-bedded fossiliferous pink calcerous sandstone	9
Cross-laminated fine-grained pink sandstone	41
Purple limestone. These beds and the subjacent ones form ledges and extensive dip-slopes along both sides of the canyon	5
Meekella beds. Dense mottled pink fossiliferous limestone	3
Salmon-pink sandstone; upper portion thin-bedded, lower portion cross-laminated. Separated from subjacent beds by marked erosion surface	5–19
——Erosion surface——	
Stenopoceras beds. White to gray calcareous sandstone containing abundant cephalopods in the upper part in the northwest corner of sec. 1, T. 14 N., R. 73 W., where it is thickest. Eastward these beds thin to a minimum of 2 feet because of the erosion surface at the top. No cephalopods present where thin	2–42
Cross-laminated red to pink sandstone	33–63
——Erosion surface——	
Pink to gray limestone with *Meekella* sp. and *Schizodus* cf. *S. wheeleri* (Swallow). Forms ledges and dip-slopes	0–11
Cross-laminated pink to red sandstone. These beds and the over-	

	Thickness in feet
lying ones are cut out by the erosion surface which occurs above and are not present along the western end of the canyon.....	0–11
Triticites beds. Pink limestone becoming gray downward and containing abundant *Triticites ventricosus*? near base. In places the overlying sandstone and limestone have been removed and these beds thinned by erosion. Forms ledges and dip-slopes and may be traced along the canyon for about 4 miles.....	13–19
Cross-laminated red sandstone....	10
?———Erosion surface———?	
Purple limestone containing small fragments of fossils; present only along east end of canyon.....	0–3
Red to pink sandstones with a number of intercalated beds of arkose grits.....	102
Gray limestone at top grading downward into arenaceous limestone which locally contains sporadic angular grains of quartz and feldspar; crinoid columnals and large planispiral gastropods are abundant in the calcareous matrix.....	9
Red to pink sandstones and arkose grits composing upper portion; lower portion of pink cross-laminated sandstone which becomes buff near base.....	94
Platy purple limestone in 3- to 4-foot beds.....	15
Arkose grits, cross-laminated pink arkosic sandstones, and limestones containing sporadic quartz and feldspar pebbles.....	78
Gray limestone containing scattered quartz and feldspar pebbles, and crinoid columnals and planispiral gastropods.....	26
Pink arkosic sandstones and arkose grits.....	100
Finely laminated cross-bedded pink arkosic sandstones, fine-grained arkose grits, and interbedded limestones which are thickly studded with quartz and feldspar pebbles. Crinoid columnals present in the calcareous beds...	47
Covered interval, with arkosic soil.	33
Pre-Cambrian granite	
The granite probably extends upward through much of the unexposed interval above.	

The Gilmore Canyon section presents definite evidence of the interdigitation of the Fountain and the Casper, and shows conclusively that, as postulated by Knight (1929) in contradiction to Lee (1927), the two formations represent contemporaneous continental and marine facies. The basal beds, although arkosic, are definitely marine, for they contain abundant crinoid columnals. Higher up are beds of coarse arkosic grit which are almost certainly of continental origin. A similar alternation of continental and marine beds characterizes the lower 325 feet of the section and hence there is no horizon at which a satisfactory dividing line can be drawn between typical Fountain beds and typical Casper beds. The highest arkose grit is about 50 feet below the *Triticites* beds.

In the Centennial Valley (fig. 1) the Fountain comprises about 670 feet of alternating arkose grits and pink sandstones which are lithologically similar to the festooned cross-laminated sandstones of the Casper along Gilmore Canyon. As now understood, the Casper in the Centennial Valley consists of a 60-foot basal cross-laminated gray sandstone, a middle 150-foot red and gray siltstone member, and an upper 40-foot cross-laminated tan sandstone. None of these members is fossiliferous and we are not able to suggest specific correlations with the Gilmore Canyon section.

The upper sandstone member of the Casper in the Centennial Valley is cut by an erosion surface with 5 or 6 feet of relief and is sharply sepa-

rated from the overlying red Satanka shale of Permian age. It has been shown that this break is probably the same as the one that separates the Tensleep sandstone and the Permian Phosphoria formation in the Wind River Mountains of west-central Wyoming (Thomas, 1934). However, no marked stratigraphic break has been distinguished between the Casper and the Satanka at the mouth of Gilmore Canyon, and there we are drawing the contact rather arbitrarily at the horizon above which red shales, a type of rock lithologically foreign to the Casper, become dominant, and above which no festooned cross-laminated sandstones are found.

Northward along the Laramie Range from Gilmore Canyon the arkosic beds in the lower part of the Casper disappear. They persist to the northwest, however, as far as Elk Mountain. At a point about 30 miles north of Laramie, near Sybille Springs (fig. 1), the formation consists of about 700 feet of alternating cross-laminated sandstones and massive limestones. The basal member is a red sandstone about 40 feet thick which rests directly on the pre-Cambrian granite. A short distance above it is a very fossiliferous limestone the fauna of which is discussed below. Sandstones are conspicuous in the upper part of the formation and one attains a thickness of about 200 feet.

Further north, near Marshall, Giddings (1935) reports a basal Casper conglomerate resting on pre-Cambrian granite and containing derived chert pebbles which carry Mississippian fossils. Above the conglomerate, about 35 feet from the granite, Giddings obtained well-preserved representatives of *Chaetetes milleporaceous* Milne-Edwards and Haime which are now in the paleontological collections of the University of Wyoming. At a near-by locality he found a lithologically similar basal sequence overlain by about 250 feet of sandstones and fossiliferous limestones, followed by about 200 feet of cross-laminated buff sandstone at the top of the formation just below the red Satanka shale. *Juresania nebrascensis* (Owen) and *Linoproductus prattenianus* (Norwood and Pratten) were obtained from the sandstone-limestone sequence, and a short distance away *Composita subtilita* (Hall), *Neospirifer dunbari* King, and *Marginifera haydenensis* Girty were found in beds about 60 feet above the granite. It is probable that this last faunule is the same as that in the lowest fossiliferous limestone near Sybille Springs.

AGE AND CORRELATION OF THE CASPER FORMATION

We are not entirely satisfied with the results of our study of the Casper fauna in so far as determining the age of the formation is concerned. The oldest known Casper fossil of value in age determination seems to be *Chaetetes milleporaceus*, which in the vicinity of Marshall, Wyoming, occurs near the base of the formation. This coral characterizes the Cherokee and Marmaton beds of Kansas, but in Texas it ranges up into the lower

Canyon group. Condra and Reed (1935) have recently reported the occurrence of *Chaetetes* about 65 feet above the base of the Hartville formation in the Hartville Uplift of Wyoming, and the containing beds there are regarded as Marmaton or older. In view of the rare occurrence of this coral in southeastern Wyoming, it might be concluded that the *Chaetetes*-bearing beds near Marshall and those in the Hartville Uplift represent the same horizon, but this conclusion, if seriously challenged, would be difficult to defend.

Near Sybille Springs we obtained a fauna from beds, about 45 feet above the pre-Cambrian granite, which probably represent a slightly higher horizon than the *Chaetetes* beds. It consists of the following forms:

Fauna of lower Casper beds near Sybille Springs, Wyo.

Bryozoans	A[1]
Lindstroemella cf. *L. patula* (Girty)	R
Derbya crassa (Meek and Hayden)?	S
Derbya sp. (large)	S
Chonetes sp.	C
Meekella sp.	R
Juresania nebrascensis (Owen)	C
Dictyoclostus portlockianus (Norwood and Pratten)	A
Dictyoclostus morrowensis (Mather)?	R
Marginifera haydenensis Girty?	A
Linoproductus prattenianus (Norwood and Pratten)	A
Wellerella aff. *W. delicatula* Dunbar and Condra	S
Dielasma bovidens (Morton) var.	C
Reticulariina? sp.	R
Neospirifer dunbari King	A
Composita subtilita (Hall)	A
Composita ovata Mather	R
Aviculopinna nebrascensis Beede	S
Edmondia aspinwallensis Meek?	R
Pleurophorus sp.	R
Myalina sp.	R
Allorisma sp.	R
Orthocerotoid fragments	R
"*Phillipsia*" sp.	R
Cladodus occidentalis Leidy	R

[1] A=abundant; C=common; S=scarce; and R=rare.

The brachiopods were examined for us by Prof. C. O. Dunbar, who has written in regard to their age as follows:

> Unfortunately, the collection is about as noncommittal as to precise horizon as would be possible. The *Lindstroemella*, if correctly identified, would suggest the Lower Pennsylvanian. This is perhaps confirmed by *Reticulariina* and *Marginifera haydenensis*. On the basis of these I should be inclined to correlate with the Des Moines, but on the other hand, it is remarkable that the really distinctive species, such as *Mesolobus*, are lacking.

In addition, Professor Dunbar pointed out to us that *Reticulariina* and a species of *Dielasma* much like the Casper form occur in the Strawn of Texas. The single shark tooth, which was identified by Dr. C. C. Branson as *Cladodus occidentalis*, seems to be of little stratigraphic value, for that species occurs in Wyoming as high as the mid-portion of the Phosphoria formation, which is Middle Permian in age. The trilobite, of which only a pygidium is known, apparently is conspecific with a form that occurs in the *Triticites* beds of the Casper at Gilmore Canyon, near Laramie.

From the portion of the Casper which we are calling the *Triticites* beds we obtained, in addition to *Triticites ventricosus* (Meek)?, *Linoproductus prattenianus* (Norwood and Pratten), *Neospirifer dunbari* King, *Composita* sp., *Allorisma* sp., crinoid columnals, and a trilobite pygidium which we are describing below as "*Phillipsia*" sp. and which is conspecific with the one we found near Sybille Springs. Dr. J. Marvin Weller has written us that these trilobites (one species represented only by

pygidia) are related to an undescribed form from the Lower Permian Luta and Fort Riley formations of Kansas, but that they are somewhat more primitive and therefore probably a little older than that form. Also, Dr. M. L. Thompson and Dr. M. K. Elias state that our fusulinids, though similar to both Upper Pennsylvanian and Lower Permian forms, are perhaps more like those known from the Wabaunsee.

The *Stenopoceras* beds of the Casper have yielded, in addition to the many cephalopods described below, numerous representatives of *Derbya* aff. *D. multistriata* (Meek and Hayden), several specimens identified by Professor Dunbar as a new species of *Orthotichia*, and rare representatives of *Pseudomonotis hawni* Meek and Hayden, *Schizodus* sp., *Myalina* sp., *Dentalium sublaeve* Hall?, and *Euphemus carbonarius* (Cox). Most if not all of the cephalopod genera represented in these beds are known to occur in both the Pennsylvanian and the Permian, and whereas the assemblage seems to be more or less typical of the Upper Pennsylvanian, it would not be incompatible with the Lower Permian. The chief difficulty in making a precise age-determination is that we know relatively little about Lower Permian nautiloids, and the only Lower Permian nautiloid fauna known from America came from the Fort Riley limestone of Kansas. Dr. N. D. Newell, who compared our forms for us with undescribed specimens of Fort Riley nautiloids in the collections of the Kansas Geological Survey, writes that whereas the genera *Metacoceras*, *Tainoceras*, *Stenopoceras*, and *Solenochilus* are common to both the Casper and the Fort Riley faunas, none of the species are particularly close, and the Fort Riley has a peculiar fauna, rather different from that of the horizons above and below, so that specific similarities would not be difficult to detect—still, the Casper brachiopod we are identifying tentatively as *Derbya* aff. *D. multistriata* (Meek and Hayden), although a new species, is closely related to both *D. multistriata* and *D. cymbula* Hall and Clarke which occur in the Fort Riley. The collections of the Kansas Geological Survey also contain an undescribed representative of *Stenopoceras* from the Lower Permian Florena shale of Kansas that is very similar to the Casper representative of that genus, but in so far as we have been able to ascertain no other similarity worthy of note exists between the faunas of the Florena and the Casper.

From the *Meekella* beds of the Casper we obtained the following:

Fauna of the Meekella *beds in the Casper formation*

Derbya aff. *D. multistriata* (Meek and Hayden)	C[1]
Meekella striatocostata (Cox)	A
Orthotichia sp.	S
Schizodus wheeleri Swallow?	C
Aviculopecten occidentalis Shumard	R
Edmondia gibbosa Swallow	R
Pleurophorus sp.	C
Deltopecten? sp.	R
Parallelodon sp.	R
Euphemus carbonarius (Cox)	R
Bellerophon sp.	C
Stenopoceras abundum Miller and Thomas	R
Metacoceras? sp.	R

[1] A=abundant; C=common; S=scarce; and R=rare.

The occurrence of *Derbya* aff. *D. multistriata*, *Orthotichia* sp., *Euphemus carbonarius*, *Stenopoceras abundum*, and *Metacoceras* sp. in both the *Meekella* beds and the underlying *Stenopoceras* beds, indicates that there is no great difference in the age of the two, in spite of the fact that a rather striking erosion surface intervenes between them.

The *Derbya* beds of the Casper have also yielded a considerable fauna, but many of the fossils obtained represent new species and others are too fragmentary to permit their specific affinities to be determined. Still, we recognize in our collections representatives of the following genera: *Polypora*, *Derbya* [aff. *D. multistriata*], *Orthotichia*, *Pseudomonotis*, *Astartella*, *Aviculopecten*, *Schizodus*, *Worthenia*, and probably *Bellerophon* and *Metacoceras*. *Derbya* aff. *D. multistriata* is abundant and *Schizodus* sp. and *Bellerophon?* sp. are not uncommon, but the rest of the forms listed are rare. This fauna is clearly related to those of the *Meekella* and the *Stenopoceras* beds, and presumably it is not greatly different in age from them.

It now seems to us, from a study of all of these faunas as well as the apparent stratigraphic relationships of the containing beds to each other, that whereas the upper part of the Casper may be Lower Permian in age, it is more probable that the entire formation is referable to the Pennsylvanian. Furthermore, the paleontological data appear to indicate that both Lower and Upper Pennsylvanian strata are present, and it seems quite probable that the Casper represents the major portion of the Pennsylvanian period. As a result of our studies we have reached the following tentative conclusions in regard to the relationships of the Casper with formation of adjacent regions:

(1) It seems probable that the Fountain sandstone of Colorado thins northward by continental overlap, so that the Fountain of the Laramie Basin, which near Laramie interfingers with marine beds of the Casper, represents only the upper

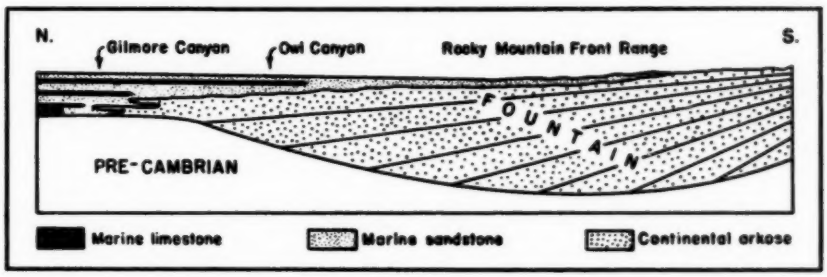

FIG. 2—Diagrammatic restored section showing (1) northward overlap of the Fountain and the interfingering of its upper part with marine beds of the lower Casper, and (2) onlapping nature of the marine beds across the eroded surface of the fan. Presumably this stage was followed by a regression of the sea.

part of the type Fountain in Colorado (fig. 2). The arkosic beds disappear north of Laramie and are replaced by marine beds of different lithology.

(2) The Ingleside formation of northern Colorado represents only the upper part of the Casper of the Laramie Basin. The unconformity which Lee described between the Fountain and the Ingleside in northern Colorado is not present in the Laramie Basin where the Fountain arkose interfingers with the sandstone-limestone facies of the Casper. Presumably the margin of the Fountain fan was built into a transgressive sea, and continued transgressions brought about the onlapping of the sandstone-limestone facies southward across the eroded surface of the fan.

(3) Northward and westward from the Laramie Basin, the change from the sandstone-limestone lithology of the Casper to the cross-laminated sandstone lithology of the Tensleep is brought about by the lensing out of the limestone tongues. Limestones persist in the lower part of the formation, but the upper part is predominantly sandstone, as shown by the Sybille Springs and Marshall sections. At certain localities in central Wyoming, the upper sandstone part has been called Tensleep and the lower limestone-sandstone part has been called Amsden, as at Alcova (fig. 1). It is probable that in places beds of Mississippian age, but younger than Madison, have been included in the "Amsden" with the lower Casper beds.

(4) The Casper limestones are probably the margins of tongues of limestones extending westward from the Hartville formation of eastern Wyoming.

(5) The disconformity which separates the Tensleep and the Phosphoria beds in the Wind River Mountains is probably the same as that which separates the Casper and the Satanka beds in the Centennial Valley (but which we could not locate in Gilmore Canyon). If, as we now believe, the Casper formation is referable to the Pennsylvanian and is of about the same age as the Tensleep, it seems logical to conclude, at least until evidence to the contrary is brought forth, that the Pennsylvanian-Permian boundary should be drawn between the Casper and the Satanka in the Laramie Basin, between the Tensleep and the redbed "Embar" (Phosphoria equivalent) in central Wyoming, and between the Tensleep and the Phosphoria in the Wind River Mountains.

SYSTEMATIC DESCRIPTIONS

FORAMINIFERA

Genus TRITICITES Girty

TRITICITES VENTRICOSUS (Meek)?

Plate 96, figures 1–5

Fusulinids are locally abundant at one horizon in the Casper formation, but apparently only one species is represented. The specimens occur firmly imbedded in a limestone matrix so that it is not possible to remove individuals. Dr. M. L. Thompson has kindly prepared oriented thin-sections of many specimens and has compiled the following detailed description of the species represented:

Shell of medium size, short, rather

highly inflated. Poles sharply pointed. Lateral slopes steep and uniform. External furrows distinct and shallow. Specimens of five volutions are about 4.4 mm. in length and 2.4 mm. in width; specimens of six volutions are about 5.8 mm. in length and 2.8 mm. in width; and specimens of seven volutions are about 6.4 mm. in length and 3.3 mm. in width. The form ratios of these same specimens are about 1:1.8, 1:2.0, and 1:1.9, respectively. However, the form ratio of mature specimens varies from 1:1.5 to 1:2.5.

The septa are numerous and rather thin. The septal count is 12 for the first volution, 17 to 20 for the second volution, 19 to 21 for the third volution, 22 to 28 for the fourth volution, and about 26 for the fifth volution. The septa are rather highly and narrowly fluted in the extreme polar regions, but only the lower portions of the septa are fluted in the central fourth of the shell, and there the fluting is very broad. The proloculum is spherical and it is very large. Its inside diameter averages about 300 microns but varies from 280 to 340 microns. The rate of expansion of the shell is essentially uniform, and the average heights of the first six volutions measure about 100, 130, 185, 240, 300, and 380 microns.

The spirotheca is thick. The keriotheca increases in thickness very rapidly from an almost invisible layer in the first volution to 42 microns in the second volution, 87 microns in the third volution, 90 microns in the fourth volution, and 105 microns in the fifth volution. The alveoli become very distinct near the end of the first volution, and they are very coarse throughout the remainder of the shell.

The tunnel is low and wide, and the tunnel angle is 36 to 37 degrees in the sixth volution. The chomata are well developed in all parts of the shell, except the outer portion of the outer volution.

Remarks.—In regard to the affinities of the Casper fusulinids, Doctor Thompson states:

> These specimens are very closely similar to the fusulinids from the upper portion of the Pennsylvanian and the lower portion of the Permian of the Mid-Continent region which have been referred by Dunbar and Condra, White, and others to *Triticites ventricosus* (Meek) and its several varieties. So many different types of specimens have been referred to that species and its varieties that it is difficult to point out even a single character that will differentiate the Wyoming specimens from all of the Mid-Continent forms. The specimens under consideration are shorter and smaller and they have a larger proloculum, better developed chomata, and apparently more rapidly thickening spirotheca than the illustrated topotypes and metatypes of *T. ventricosus* from the Hughes Creek shale at Manhattan, Kansas. However, some of the specimens from the Hughes Creek at Eis Hill, Nebraska, which Dunbar and Condra figured as *T. ventricosus*, do not differ from the Wyoming specimens in all of the features listed. The specimens from the Saddle Creek limestone of Texas which White described as *T. ventricosus* "third sample" agree very closely with the Casper forms in so far as size, shape, development of chomata, size of proloculum, and rate of expansion of shell are concerned, but it is clear from the figures given by White for the thickness of the spirotheca in the different volutions that the spirotheca of the Texas specimens is much thinner than that of the Wyoming form.

We sent photographs of our specimens to Dr. M. K. Elias so that they could be compared directly with the numerous thin-sections of Mid-Continent fusulinids in the collections of the Kansas Geological Survey. He has written us (personal communication, dated March 12, 1936) that our fusulinids

> seem to belong to *Triticites ventricosus* in a broad sense, but this common form ranges through the Wabaunsee and the Big Blue . . . [but the Wyoming specimens] seem to be more like those from the Wabaunsee.

Occurrence.—Abundant in *Triticites* beds of Casper formation, in Gilmore Canyon, about 8 miles southeast of Laramie, Wyoming.

Figured specimens.—Univ. Iowa, nos. 1140–1144.

CEPHALOPODA

Genus PSEUDORTHOCERAS Girty

PSEUDORTHOCERAS KNOXENSE (McChesney)

Plate 96, figures 6, 7

Recently Miller, Dunbar, and Condra (1933) have described this species in detail and have listed its extensive synonymy. This species is not rare in the Casper formation, but we obtained only fragmentary moderate-sized representatives of it. These are in all respects typical and those that are well preserved show all of the characteristic features: long slender conch, simple septa and sutures, central siphuncle composed of pyriform segments, and lamellar deposits in the camerae next to the walls of the phragmacone (pl. 96, fig. 6).

We have not seen the specimens (or specimen) from the same general horizon and locality as ours which Girty (Darton, 1908) identified as "*Orthoceras* sp.," but it seems likely that they represent this species. They may, however, represent the form described below as *Mooreoceras?* sp., or, of course, they may represent both or be distinct from both.

Occurrence.—This species is widely distributed both geographically and stratigraphically in the Pennsylvanian of North America, and it may occur also in the Upper Carboniferous of Europe. Stratigraphically it ranges from the Cherokee at least to the Wabaunsee and from the Bend to the Cisco; and geographically it is known from Pennsylvania to Colorado, and from Texas to Michigan. Also, Misch and Heritsch have recently referred to this species some specimens from the Upper Carboniferous near Nassfeld, in the Carnic Alps on the Austro-Italian border, and in so far as we are able to tell from their descriptions and illustrations, these specimens do not differ essentially from the American forms. Girty (1915) indirectly referred some Lower Permian forms to this species by placing references to them in its synonymy, and whereas it does not seem improbable that this species ranges into the Permian, all of the numerous Permian cephalopods that we have sectioned belong in different genera. The Casper specimens we are studying all came from the *Stenopoceras* beds, in Gilmore Canyon, about 8 miles southeast of Laramie, Wyoming.

Figured specimens.—Univ. Iowa, nos. 1147, 1148.

Genus MOOREOCERAS Miller, Dunbar and Condra

MOOREOCERAS(?) sp.

Plate 97, figure 1

In a few of the straight cephalopods in our collections from the Casper, the

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EXPLANATION OF PLATE 96

All specimens illustrated came from the Casper formation, in Gilmore Canyon, about 8 miles southeast of Laramie, Wyoming.

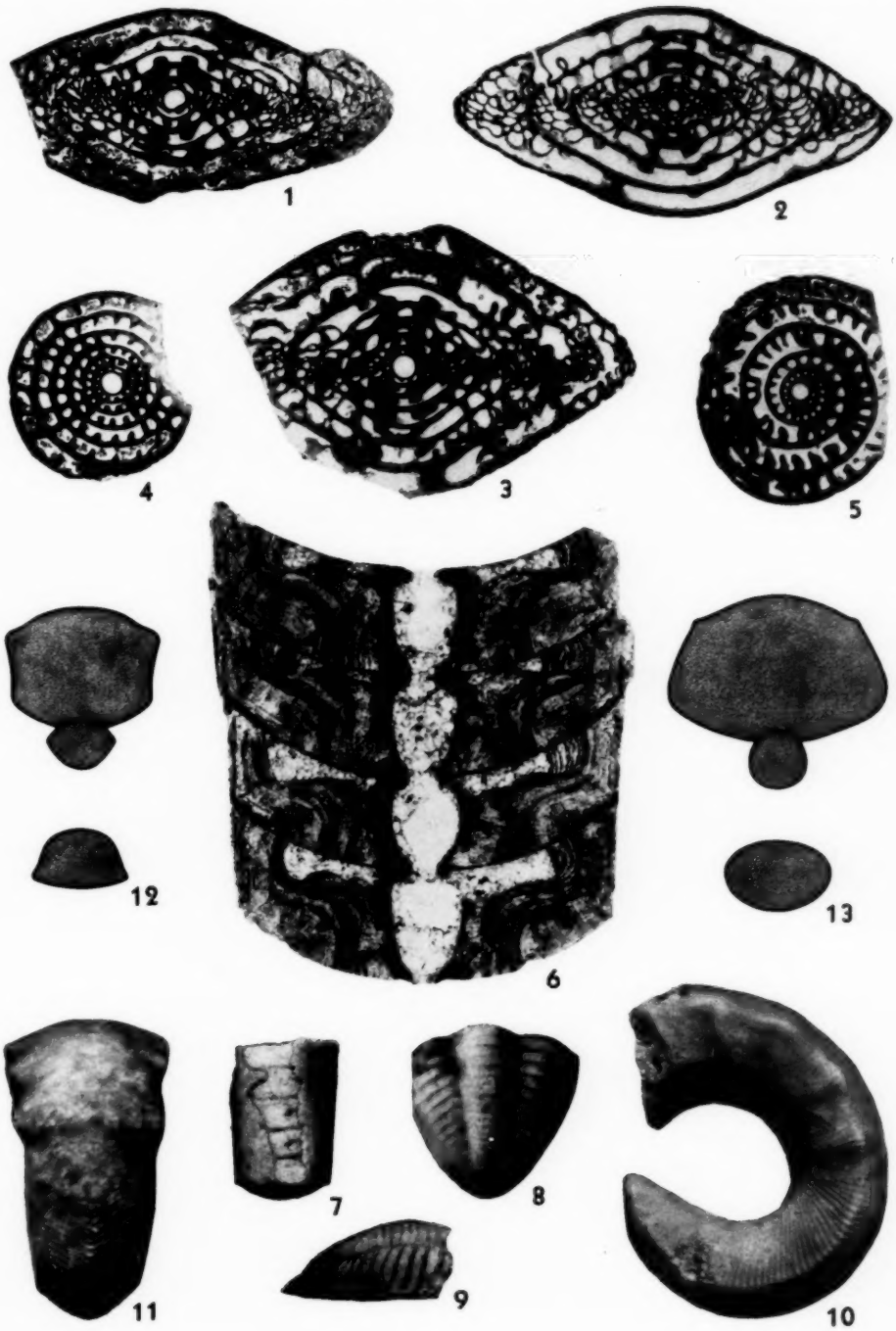
FIGS. *1–5*—*Triticites ventricosus* (Meek)? Axial and sagittal sections (unretouched photographs) of typical specimens, ×10. *Triticites* beds. (p. 724)

6, 7—*Pseudorthoceras knoxense* (McChesney). Median longitudinal section (unretouched photograph) of a typical specimen, showing the siphuncle and the lamellar deposits in the camerae next to the walls of the phragmacone, ×8; and lateral view of another typical specimen, ×2. *Stenopoceras* beds. (p. 726)

8, 9—*Ameura* sp. Dorsal and lateral views of an essentially complete pygidium, ×2. *Triticites* beds. (p. 737)

10–12—*Metacoceras* sp. *10, 11*, Lateral and ventral views of an immature specimen (Univ. Iowa, no. 1153), ×4, and diagrammatic cross section, ×2, showing shape and surface markings of conch during early growth stages. *12*, Composite figure based on Univ. Iowa specimens nos. 1153, 1154. *Stenopoceras* beds. (p. 730)

13—*Tainoceras wyomingense* Miller and Thomas, n. sp. Diagrammatic cross section, showing shape of conch during early growth stages, ×2. *Stenopoceras* beds. [See pl. 97, fig. 6 and pl. 98, figs. 3, 4.] (p. 732)



Miller and Thomas, Pennsylvanian Invertebrates

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siphuncle is located distinctly ventrad of the center of the conch and there are no peripheral deposits in the camerae. Therefore, these forms can be differentiated readily from the more abundant *Pseudorthoceras knoxense* (McChesney), described above. The conch is long, slender, straight, gradually expanded orad, and circular or broadly elliptical, in cross section, being slightly depressed dorso-ventrally; it attains a diameter of at least 30 mm. The test is thin and is marked externally by only straight or slightly sinuous transverse growth-lines, which on some specimens are quite distinct. The septa are simple saucer-shaped disks, moderately convex apicad, and the camerae are of average length (see pl. 97, fig. 1). The sutures are straight or only very slightly sinuous, and they are transverse to the long axis of the conch. Due to the poor preservation of our specimens, we have not been able to ascertain with certainty the structure of the siphuncle, and therefore we can not refer them definitely to any genus. However, in one of the sectioned specimens we encountered structures which probably represent siphuncular segments, and they are fusiform in shape as in the Late Paleozoic genus *Mooreoceras*. Since the other characters of our specimens coincide precisely with those of typical representatives of that genus, we are referring our form to it with question.

Occurrence.—*Stenopoceras* beds of Casper formation, in Gilmore Canyon, about 8 miles southeast of Laramie, Wyoming.

Figured specimen.—Univ. Iowa, no. 1150.

Genus COLOCERAS Hyatt

COLOCERAS sp.

Plate 98, figures 5, 6

We obtained only a single representative of *Coloceras* from the Casper. It is rather small and septate throughout, presumably representing only the adapical, immature portion of the phragmacone. It is only a little more than a volution in length and is subglobular in shape, attaining a maximum diameter (measured across the umbilicus) of about 14 mm. and a maximum width and height of conch of about 11½ mm. and 8½ mm., respectively. The conch is expanded orad rather rapidly and at the adapical end of the outer volution of the specimen, the conch is only about 5 mm. wide and 3 mm. high. Whorls are broadly rounded ventrally, somewhat more narrowly rounded laterally, impressed dorsally, and reniform in cross section.

Umbilicus, which appears to be perforate, is rather small, and its diameter is equal to only about one-fifth that of specimen. Umbilical shoulders rounded and not very distinct, though they appear to increase in prominence adorally. Umbilical walls rounded.

No trace of surface markings is discernible on adoral part of specimen, which is not very well preserved. However, on portions of the test, or a replacement of it, which adhere to the adapical part of the outer volution of the specimen there are rather prominent longitudinal lirae or raised lines; these are about one-fifth mm. apart. Traces of the growth-lines on the preserved portions of the test indicate that the conch is marked ventrally by a moderately deep rounded hyponomic sinus and laterally by similar but more broadly rounded salients.

Camerae moderate in length. Sutures are not very distinct on this specimen but they appear to be essentially straight and to be directly transverse to long axis of conch. Siphuncle subcentral in position but distinctly nearer dorsum than venter.

Remarks.—The genus *Coloceras* is widely distributed both geographically and stratigraphically. It is well represented in the Mississippian, Pennsylvanian, and Permian of both Europe and North America, and it occurs also in Asia. In North America it is known to range from the Upper Mississippian (Chester) to the Lower Permian (Wich-

ita), but it seems to be abundant only in the Pennsylvanian. The longitudinal lirae on the adapical portion of the outer volution of the above-described specimen are not a specific character, for similar lirae have been observed on the adolescent portion of the conch of more than one species of *Coloceras*. Since this specimen apparently is not mature, it can not be identified specifically and it is therefore of little stratigraphic value.

Occurrence.—*Stenopoceras* beds of Casper formation, in Gilmore Canyon, about 8 miles southeast of Laramie, Wyoming.

Figured specimen.—Univ. Iowa, no. 1152.

Genus METACOCERAS Hyatt

METACOCERAS KNIGHTI Miller and Thomas, n. sp.

Plate 97, figures 2, 3

Conch, which at maturity consists of at least three or four volutions, is subdiscoidal, nautiliconic though only slightly involute, and large, attaining a diameter (measured across the umbilicus) of at least 115 mm. and a maximum height and width of conch of at least 45 mm. and 55 mm., respectively. Extreme adapical portion of conch is rapidly expanded and is circular or nearly so in cross section. However, lateral diameter increases more rapidly than dorso-ventral diameter, and conch becomes depressed very early in its ontogenetic development. During the first volution the dorsal side of the conch is less strongly arched than the ventral side, and the cross section of the conch is subelliptical. Immediately orad of the first volution of the conch umbilical shoulders are gradually developed and at about the same time there appears on the ventro-lateral zones of the conch a low narrow ridge—the lateral walls of the conch are thus defined and the whorls become subrectangular in cross section, which shape is retained throughout ontogenetic development. At full maturity the ventral part of the conch is gently convex, the lateral walls which converge slightly ventrad are nearly straight, and the dorsal part is composed of three divisions—nearly straight umbilical walls separated by a median shallow rounded impressed zone. Both the ventro-lateral and the dorso-lateral zones of the conch are subangular.

Umbilicus large and perforate. Its diameter is equal to about one-half that of specimen. Umbilical perforation is oval in shape and it is about 4 mm. wide and 5 mm. long. Umbilical walls moderately steep.

Apertural margins not retained on any of the numerous specimens available for study, but growth-lines are essentially straight and directly transverse on umbilical walls and lateral sides of conch, and form broad deep rounded sinuses on ventral side (pl. 97, fig. 2). With exception of the growth-lines, the first volution of the conch is smooth or nearly so, though at the adoral end of the first half-volution there is a slight but very distinct constriction. On the adapical portion of the second volution of the conch a low narrow ridge appears on each of the

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EXPLANATION OF PLATE 97

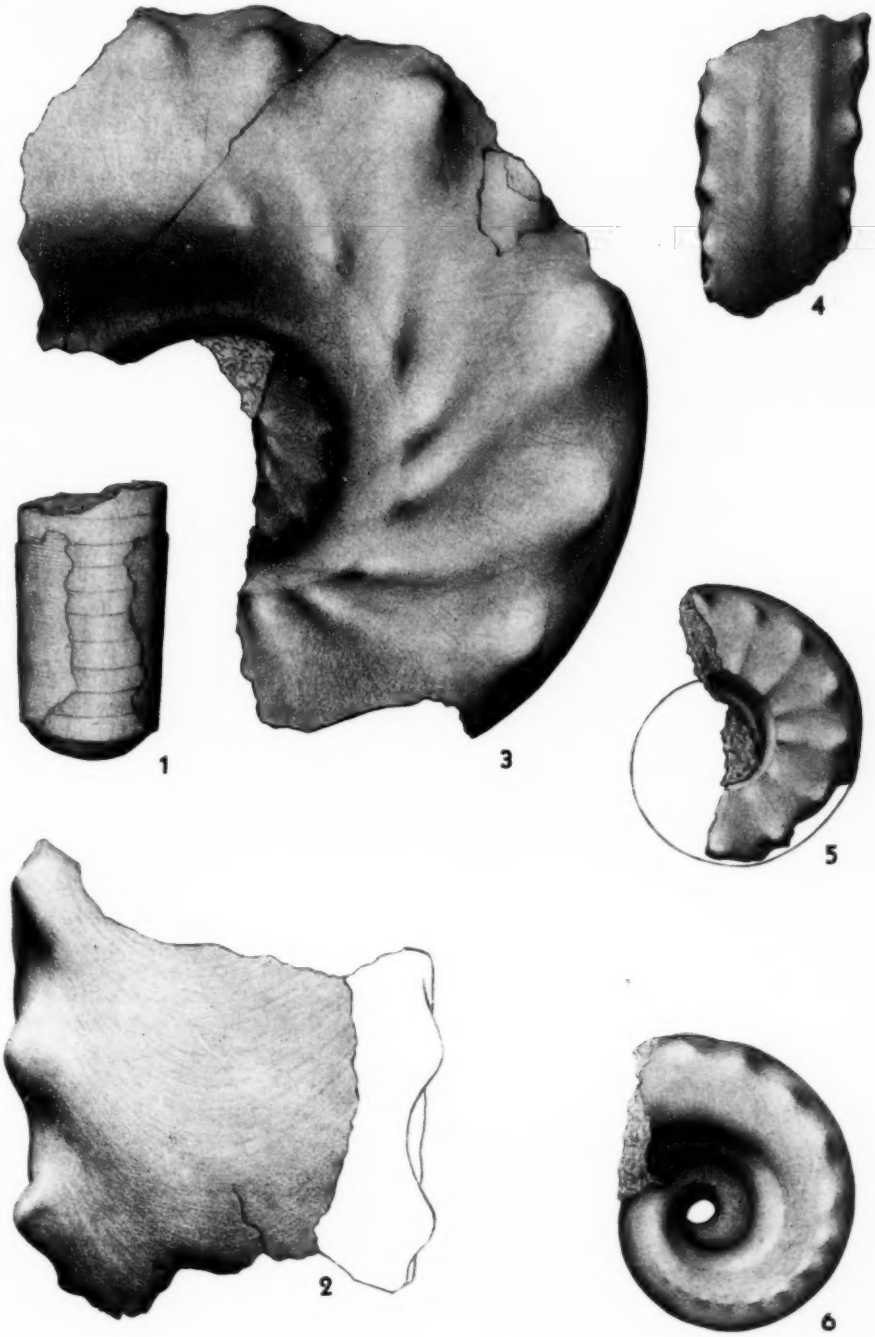
All specimens illustrated on this plate came from the *Stenopoceras* beds of the Casper formation, in Gilmore Canyon, about 8 miles southeast of Laramie, Wyoming. Drawings by Dan Enich.

FIGS. *1*—*Mooreoceras* (?) sp. Ventral view of an average specimen, somewhat restored, ×1. (p. 726)

2, 3—*Metacoceras knighti* Miller and Thomas, n. sp. Ventral and lateral views (somewhat restored) of a typical large specimen (a syntype), ×1. (p. 728)

4, 5—*Metacoceras sulciferum* Miller and Thomas, n. sp. Ventral and lateral views of a typical mature specimen (a syntype), ×1. (p. 729)

6—*Tainoceras wyomingense* Miller and Thomas, n. sp. Lateral view of an immature specimen (a syntype), showing the umbilical perforation, the gradual development of the ventro-lateral nodes, and the appearance of the ventral nodes near the adoral end of the specimen, ×1. [See pl. 96, fig. 13, and pl. 98, figs. 3, 4.] (p. 732)



Miller and Thomas, Pennsylvanian Cephalopods

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ventro-lateral zones. During the first quarter of the second volution these ridges become nodose and each is transformed into a row of longitudinally elongate nodes. These nodes soon develop lateral extensions, and gradually they become obliquely elongate (pl. 97, fig. 3). Orad of the first volution of the conch umbilical shoulders are developed, and these also gradually become nodose during ontogenetic development. The nodes on them likewise become obliquely elongate. Throughout ontogenetic development there is a distinct tendency for the umbilical nodes to be paired with the ventro-lateral nodes.

At maturity the sutures are like those of typical representatives of *Metacoceras;* that is, each mature suture forms a broad shallow rounded lobe on the ventral, the lateral, and the dorsal sides of the conch, and these are separated by subacute saddles. The part of the suture forming the dorsal side of the lateral lobe continues to curve orad across the umbilical wall, and the subacute dorso-lateral saddle centers on the umbilical seam rather than on the umbilical shoulder; there is, however, a marked decrease in the amount of adoral curvature of the sutures on the umbilical shoulder. The siphuncle is small, circular in cross section, subcentral in position (but distinctly nearer the venter than the dorsum), and apparently orthochoanitic in structure—at any rate it is composed of cylindrical segments.

Remarks.—This fine, large species is named for Prof. S. H. Knight, in recognition of his work on the Casper formation. Its most distinctive characters are the large size of its conch, the oblique elongation of the ventro-lateral nodes, and the obliquely elongate nodes on the umbilical shoulders. In only a few of the previously described representatives of *Metacoceras* do the umbilical shoulders bear nodes, and in none of them are the nodes obliquely elongate. In the form from the Casper that we are describing below as *M. sulciferum* the ventral side of the conch is marked centrally by a shallow rounded longitudinal groove.

Occurrence.—Abundant in *Stenopoceras* beds of Casper formation in Gilmore Canyon, about 8 miles southeast of Laramie, Wyoming.

Syntypes.—Univ. Iowa, nos. 1155, 1156.

METACOCERAS SULCIFERUM Miller and Thomas, n. sp.

Plate 97, figures 4, 5

Associated with the numerous large specimens described as *M. knighti* are a few smaller, moderate-sized specimens which differ from equal-sized portions of typical representatives of *M. knighti* in that the ventral side of their conch is marked medianly by a shallow rounded longitudinal groove. In some specimens this groove is very prominent, whereas in others it is small and shallow and is easily overlooked. Nevertheless, these forms can be readily differentiated from typical *M. knighti.*

Conch forms at least two and one-half volutions, and it is subdiscoidal and nautiliconic though only slightly involute. It attains a maximum diameter, measured across the umbilicus, of at least 37½ mm. and a maximum height and width of conch of at least 13 mm. and 23 mm., respectively. Extreme adapical portion of conch is circular or nearly so in cross section, but throughout most of the first volution the conch is depressed dorso-ventrally and is subelliptical in cross section, its ventral side being more strongly convex than its dorsal. By the time the conch has completed one full volution both umbilical and ventro-lateral shoulders have started to develop, and these rapidly become subangular; the conch then becomes subrectangular in cross section. Even after the conch has attained full maturity, however, its lateral walls, which are nearly straight, converge ventrad, and its ventral and dorsal sides, though concave medianly, are in general convex.

Diameter of umbilicus is equal to

about one-half that of specimen. Umbilicus is perforate and umbilical perforation is oval in shape and is about 5 mm. long and 4 mm. wide. Umbilical walls are steep.

Growth-lines are nearly straight on umbilical walls and lateral parts of conch, but they form very shallow subangular sinuses as they cross the umbilical shoulders and broad deep rounded sinuses as they cross the ventral side of the conch. First volution of conch is essentially smooth, but thereafter a row of longitudinally elongate nodes with low rounded inconspicuous lateral extensions is developed on each of the ventro-lateral shoulders of the conch. After the conch has completed almost two volutions a row of similar but smaller nodes is developed on each of the umbilical shoulders. The nodes on the umbilical shoulders also bear lateral extensions, and they seem to be paired with those on the ventro-lateral zones of the conch. There are about 15 or more of these nodes to the volution.

In so far as we have been able to ascertain, the sutures of this species are like those of all typical representatives of *Metacoceras*, and they do not differ materially from those of *M. knighti*. The siphuncle, like that of *M. knighti*, is orthochoanitic in structure, or at any rate it is composed of cylindrical segments. Where the conch is about 15 mm. high, the center of the siphuncle is about 5 mm. from the venter and about 8 mm. from the dorsum, the impressed zone being about 2 mm. deep.

Remarks.—The most distinctive character of this species, which has suggested its name, is the longitudinal furrow along the venter. It may be that the specimens on which we are basing this species should be regarded as aberrant representatives of *M. knighti*, or as representing a variety of that species, but it now seems to us best to regard them as belonging in a distinct species.

Occurrence.—*Stenopoceras* beds of Casper formation, in Gilmore Canyon, about 8 miles southeast of Laramie, Wyoming.

Syntypes.—Univ. Iowa, nos. 1157, 1158.

METACOCERAS sp.

Plate 96, figures 10–12

From the *Stenopoceras* beds of the Casper formation we obtained numerous specimens which apparently are referable to *Metacoceras*, but many of them are poorly preserved and incomplete and others are small and presumably immature. There seems to be a great deal of variation among these specimens, and due to their fragmentary nature we have not been able to determine just which of the small, immature specimens are conspecific with certain of the large ones.

A few of the small specimens are ex-

EXPLANATION OF PLATE 98

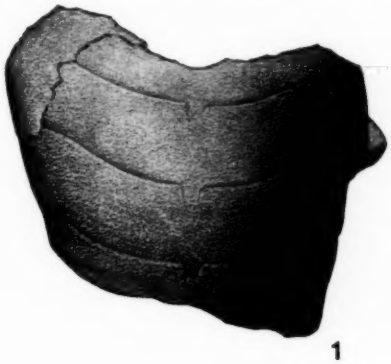
All specimens illustrated on this plate came from the *Stenopoceras* beds of the Casper formation, in Gilmore Canyon, about 8 miles southeast of Laramie, Wyoming. Drawings by Dan Enich.

FIGS. *1, 2*—*Solenochilus* cf. *S. brammeri* Miller, Dunbar, and Condra. Ventral and lateral views of a fairly well preserved but rather small specimen representing a late adolescent or early mature portion of the conch, ×1. (p. 736)

3, 4—*Tainoceras wyomingense* Miller and Thomas, n. sp. Lateral and ventral views of two of the syntypes (mature specimens), both ×1. [See pl. 96, fig. 13, and pl. 97, fig. 6.] (p. 732)

5, 6—*Coloceras* sp. Lateral and ventral views (somewhat restored) of the only representative of *Coloceras* known from the Casper formation, ×2. (p. 727)

7–10—*Stenopoceras abundum* Miller and Thomas, n. sp. Lateral view of an immature specimen (a syntype) of about two volutions showing the start of the abrupt closure of the umbilicus; ventral and lateral views of another syntype of about one and one-half volutions showing the shape of the conch and the perforate umbilicus during early ontogenetic development; and lateral view of extreme adapical portion of conch; all ×1. [See pl. 99, figs. 1, 2.] (p. 734)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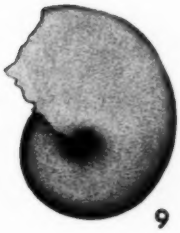
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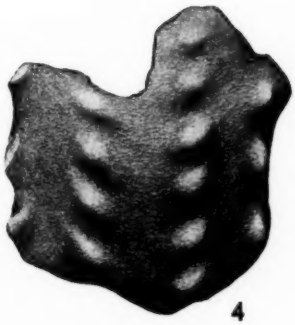
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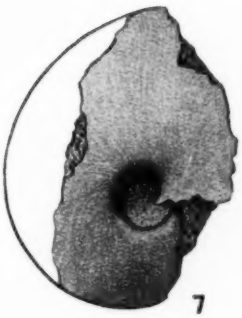
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ceptionally well preserved. Some of these represent the extreme adapical portion of the conch and are therefore worthy of consideration even though we can not be certain of their specific affinities. One of these, which does not complete a full volution, is figured (pl. 96, figs. 10–12). Its extreme adapical part, which is expanded orad very rapidly, is circular or nearly so in cross section, but its lateral diameter increases more rapidly than its dorso-ventral diameter, and it becomes subelliptical in cross section very early in its ontogenetic development, the ventral side being less strongly convex than the dorsal. At the same time that the conch becomes depressed it develops lateral keels which migrate to a ventro-lateral position. After the conch has completed almost one-half of a volution these keels are abruptly transformed into rows of very prominent longitudinally elongate nodes, each of which possesses a low rounded lateral extension. Soon umbilical shoulders are developed and the lateral parts of the conch are defined. At first these converge dorsad rather strongly, but they gradually become more nearly parallel. The adapical non-nodose portion of the conch is marked by very prominent transverse lirae which presumably represent increments of growth. Each of these forms a narrowly rounded ventral sinus which becomes progressively deeper and more nearly V-shaped during ontogenetic development, and on each side of it a broad gently rounded salient, a shallow subangular sinus which centers on the lateral or ventro-lateral keel, and a broad rounded dorsal salient which extends from one of the keels to the other. At the same time that the conch develops lateral nodes, these transverse lirae become much reduced in size and prominence, and they are thus transformed into typical growth-lines. As umbilical shoulders are developed the growth-lines become straight on the lateral walls of the conch, and then dorso-lateral sinuses are rapidly developed. It should perhaps be mentioned in this connection to avoid possibility of ambiguity that the dorsal side of the conch does not become concave until after a full volution is completed, and a dorsal impressed zone is then gradually developed—that is, in contrast to *Stenopoceras*, an impressed zone is not developed until it is needed.

Remarks.—The early growth-stages of *M. knighti* differ markedly from those of the above described form. The conch of *M. knighti* is non-nodose until it has completed about one and one-fourth volutions. Umbilical shoulders are gradually developed immediately orad of the first volution, and at about the same time a low narrow ridge appears on each of the ventro-lateral zones of the conch. During the first quarter of the second volution this ridge becomes nodose, and it gradually evolves into the nodose ventro-lateral zones of the conch. This species, then, during its ontogenetic development does not seem to pass through a *Temnocheilus* stage as does the form described above, but it may be said to pass directly from an *Endolobus* to a *Metacoceras* stage, suggesting that the genus *Metacoceras* as now understood may not be monophyletic.

The early growth stages of the Casper representative of *Tainoceras*, *T. wyomingense* Miller and Thomas, differ markedly from those of the small *Metacoceras* described above (compare figs. 12 and 13 of pl. 96), but in general they are similar to those of *M. knighti*. In *T. wyomingense* after the conch has completed a little over half of a volution low broad inconspicuous lateral nodes appear. Soon after the conch completes the first volution these lateral nodes disappear, umbilical shoulders become distinct, and a row of longitudinally elongate nodes is then developed rather gradually on each of the ventro-lateral shoulders. Near the mid-length of the second volution of the conch, two rows of longitudinally elongate nodes are gradually developed on the ventral side of the conch. In this species, as in the representatives of *Meta-*

coceras discussed above, a dorsal concave zone is not developed until the conch has completed a full volution and an impressed zone is necessary if the conch is to become involute.

Genus TAINOCERAS Hyatt

TAINOCERAS WYOMINGENSE Miller and Thomas, n. sp.

Plate 96, figure 13; Plate 97, figure 6; Plate 98, figures 3, 4

(?) *Tainoceras occidentale* GIRTY, *1908*, Geol. Soc. America, Bull., vol. 19, p. 429.

Conch, which forms at least three volutions, is subdiscoidal, nautiliconic, and rather large at maturity. One of the syntypes attains a maximum diameter, measured across the umbilicus, of about 60 mm. and a maximum height and width of conch of about 25 mm. and 35 mm., respectively; and another crushed fragmentary syntype, which represents only a portion of one volution of the conch, is at least 25 or 30 per cent larger. Mature whorls are depressed dorso-ventrally and are octagonal in cross section (see text-figure 3A). Ventral, ventro-lateral, and dorso-lateral sides of conch are relatively narrow, compared with lateral and dorsal sides. Except near apex, where conch is circular or nearly so in cross section, adapical portion of conch is subelliptical in cross section, being strongly depressed dorso-ventrally, very broadly rounded ventrally and dorsally, and rather narrowly rounded laterally; dorsal side of conch is less strongly convex than ventral (see pl. 96, fig. 13). Conch is expanded orad rapidly, and at adoral end of first volution it is about 12½ mm. wide and 8 mm. high. One-half volution orad of this point it is about 20 mm. wide and 12½ mm. high.

Umbilicus moderately large and perforate. In large mature individuals diameter of umbilicus is equal to nearly one-half diameter of specimen, and in younger individuals it is relatively larger. Umbilical perforation is oval in shape and it is about 5 mm. long and 3 mm. wide. Umbilical walls steep; umbilical shoulders subangular and at full maturity slightly nodular.

On mature portion of conch each growth-line forms a broad moderately deep rounded ventral sinus and on each side of it a broad low gently rounded lateral salient, but growth-lines are essentially straight and directly transverse on umbilical walls. Adapical portion of conch is smooth or nearly so but near adoral end of adapical volution lateral zones of conch become very slightly nodular, and on adapical portion of next volution there is developed rather gradually on each of the ventro-lateral shoulders of the conch a row of longitudinally elongated nodes. Near the mid-length of the second volution of the conch two rows of similar nodes are gradually developed on the ventral side of the conch. Apparently the nodes in all four of these rows continue to enlarge throughout ontogenetic development, and they seem to become progressively less elongated longitudinally. Nevertheless, on large specimens the ventro-lateral nodes are distinctly elongated longitudinally and the ventral nodes are elongated obliquely (pl. 98, fig. 4). During full maturity the ventral nodes become as large and prominent as the ventro-lateral nodes and also the umbilical shoulders become slightly nodular.

Camerae moderate in length (see pl. 98, fig. 3). As shown in text figure 3B, each mature suture forms broad shallow rounded ventral, lateral, and dorsal lobes, and these are separated by subangular saddles. As a result of the ventral nodes, the flanks of the ventral lobe are sinuous. Also, it should be noted that on the umbilical shoulder there is an abrupt change in the curvature of the sutures, and that on the umbilical walls the sutures are essentially straight. Siphuncle small, circular in cross section, and subventral in position.

Remarks.—In 1908 Girty studied a specimen (or specimens) from the same general horizon and locality as the types of the above-described species, and he

referred it to *Tainoceras occidentale*. We have not seen that specimen, but it seems likely that it is conspecific with the form under consideration, which differs considerably from *T. occidentale* as now understood.

The genus *Tainoceras* is abundantly represented in the Pennsylvanian and Lower Permian of the United States, and it has been found also in the Upper Carboniferous and Permian of Europe and the Upper Carboniferous of Asia (near Vladivostok). In the United States it is widespread both geographically and stratigraphically and ranges from Pennsylvania to Colorado; stratigraphically it ranges throughout most of the Pennsylvanian and well up into the Lower Permian (upper Wichita). In Europe it has been found in the Upper Carboniferous of Russia (near Moscow), the Sosio beds (Middle Permian) of Sicily, and the *Bellerophon* limestone (Upper Permian) of the Dolomite Alps. The species under consideration is not closely similar to most of the European and Asiatic forms but it is somewhat similar to *T. trautscholdi* (Waagen) of the Upper Carboniferous of Russia (near Moscow), *T. nebrascense* Miller, Dunbar, and Condra of the Lower Permian (Hughes Creek shale and Fort Riley limestone) of Nebraska, the specimen from some unknown horizon and locality which Miller, Dunbar, and Condra illustrated and described in 1933 as *Tainoceras* sp., and the specimens from the Lower Permian (Wichita formation) of Texas which Hyatt illustrated and described in 1893 and erroneously referred to *T. quadrangulum* (McChesney). *T. wyomingense* is readily distinguished from all of these forms by means of the shape of the cross section of its conch and the size, shape, and position of the nodes.

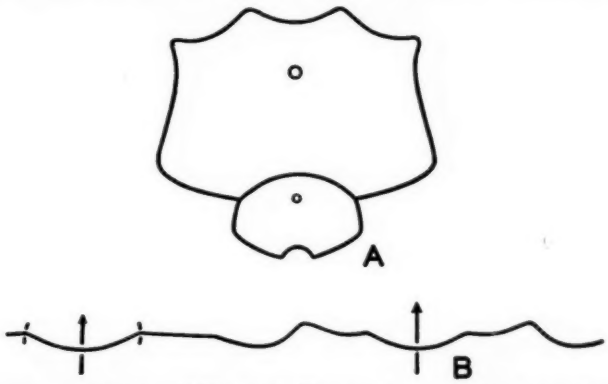

FIG. 3—*Tainoceras wyomingense* Miller and Thomas, n. sp. Diagrammatic cross section of ultimate and penultimate volutions of conch, and diagrammatic representation of a mature suture, both ×1. B is based on specimen represented by figure 3 on plate 98, whereas A is a composite figure and is based on specimens represented by figures 3 and 4 on plate 98. Both of these specimens are syntypes.

In 1893 Hyatt stated that during ontogenetic development representatives of *Tainoceras* pass through first a *Temnocheilus* and then a *Metacoceras* stage before assuming their own generic characters. *T. wyomingense* passes through a *Metacoceras* stage during late adolescence but its early adolescent stage (with subelliptical conch and low lateral nodes) is not at all like *Temnocheilus* but is reminiscent of *Endolobus*.

Occurrence.—Abundant in *Stenopoceras* beds of Casper formation, in Gilmore Canyon, about 8 miles southeast of Laramie, Wyoming.

Syntypes.—Univ. Iowa, nos. 1159–1163.

Genus STENOPOCERAS Hyatt

STENOPOCERAS ABUNDUM Miller and Thomas, n. sp.

Plate 98, figures 7–10; Plate 99, figures 1, 2

Ammonoid indet. GIRTY, 1908, Geol. Soc. America, Bull., vol. 19, p. 429.

Our collections from the Casper contain some 45 specimens that are referable to the genus *Stenopoceras*, but all of these seem to represent only one species. Most of them are rather incomplete and fragmentary, but they supplement one another very well and a great deal of detailed information can be gleaned from them.

Conch, which forms at least three volutions, at maturity is sublenticular in shape, nautiliconic in its mode of growth, and large, attaining a maximum diameter (measured across the umbilicus) of more than 125 mm., and a maximum height and width of conch of at least 70 mm. and 35 mm., respectively. Extreme adapical portion of conch is circular (or essentially so) in cross section, but dorsoventral diameter of conch is increased much more rapidly than lateral diameter and very early in its ontogenetic development conch becomes oval in cross section, being much more narrowly rounded ventrally than dorsally. Following this stage of development, dorsal side of conch becomes flat, and before conch has completed the first half-volution its dorsal side is distinctly concave (see text figure 4A). At first the dorsal concave zone is broad, shallow, and broadly rounded, but it becomes progressively deeper and relatively narrower, and by the time the conch has completed one and one-half volutions it is impressed dorsally to almost two-fifths its height (pl. 98, fig. 8). It should be stated unambiguously that a dorsal concave zone is developed long before the conch completes one volution and becomes involute; that is, it almost seems as though an impressed zone is developed before it is needed. After the conch has completed about one volution, its broad lateral walls become noticeably more and more flattened; and its ventral side, which has become very narrow, is also gradually flattened and ultimately (after conch has reached a height of about 35 mm.) it becomes concave. The lateral walls of the conch converge ventrally and the cross section of the whorls is cordate during adolescence but subsagittate (though slightly concave ventrally) at maturity. Apertural margins are not preserved on any of our specimens, but living chamber is at least one-fourth of a volution in length.

At maturity umbilicus is small and closed, and the umbilical shoulders are broadly rounded and very indistinct. During early growth stages the umbilicus is small but perforate, the umbilical perforation being oval in shape and, after the conch has completed one volution, about 4 mm. long and 3 mm. wide. During the next half-volution the umbilicus appears to become smaller; then it seems to become larger, only to be closed rather abruptly after the conch has completed a little more than two volutions (pl. 98, fig. 7).

Test thin, and even on large mature specimens it does not seem to have been more than 1 mm. thick. Surface of test smooth and marked only by growth-lines, which are fine and though very distinct are not particularly prominent. At full maturity each growth-line forms a deep rounded ventral sinus, a shallower rounded ventro-lateral salient (which centers on the ventral portion of the flattened lateral side of the conch, a

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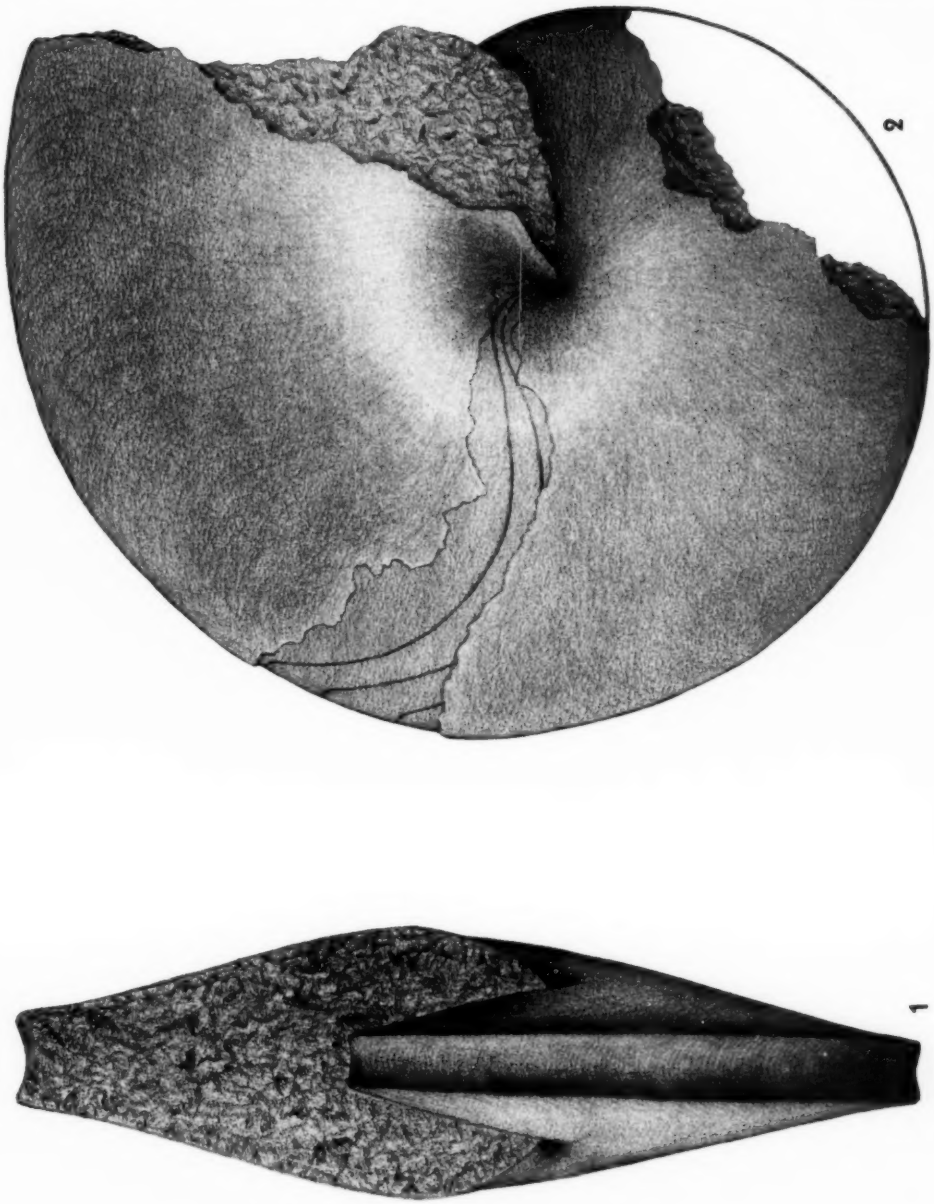
EXPLANATION OF PLATE 99

FIGS. *1, 2*—*Stenopoceras abundum* Miller and Thomas, n. sp. Ventral and lateral views (somewhat restored) of a large mature specimen (a syntype) from the *Stenopoceras* beds of the Casper formation, in Gilmore Canyon, about 8 miles southeast of Laramie, Wyoming, ×1. [See pl. 98, figs. 7–10.] (p. 734)



Miller and Thomas, Pennsylvanian Cephalopods

UNIV. OF MICH.

broad shallow broadly rounded lateral sinus, and a similar but smaller dorso-lateral salient which centers slightly dorsad of the umbilical shoulders (pl. 99, figs, 1, 2). On the penultimate volution of the conch the growth-lines are in general similar to those on the ultimate volution but the lateral sinus is relatively narrow and the ventro-lateral salient is relatively broad.

Septa rather close together and camerae therefore numerous and rather short (pl. 99, fig. 2). At maturity each suture forms a high rather narrow ventral saddle in the center of which there is a shallow broadly rounded lobe which results from the concavity of the ventral side of the conch, and on each side of it there is a broad deep gently rounded lateral lobe, a much smaller rounded dorso-lateral saddle which centers on the umbilical wall, a similar but slightly smaller lobe which centers on the umbilical seam, and a similar internal lateral saddle which extends to the dorsal lobe. The dorsal lobe is moderate in size and it is depressed-V-shaped but truncated.

Siphuncle small, circular in cross section, and intermediate in position. Where the conch is about 35 mm. high the siphuncle is about 1 mm. in diameter and is located about 1 mm. from the venter. Unfortunately, we were not able to determine the structure of the siphuncle.

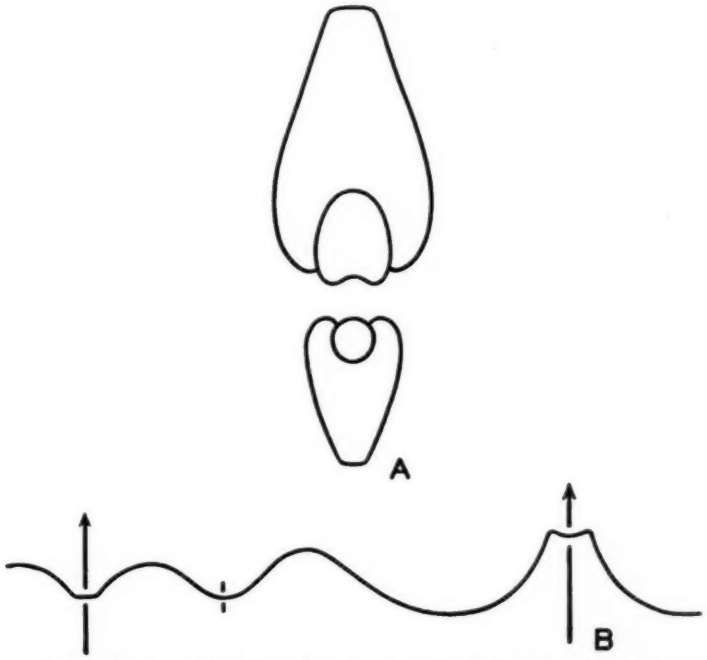


FIG. 4—*Stenopoceras abundum* Miller and Thomas, n. sp. Diagrammatic cross section of early volutions of conch, ×1½, and diagrammatic representation of a mature suture, ×1, both based on syntypes.

Remarks.—Only a few representatives of *Stenopoceras* have been mentioned in the literature. These came from the Fort Riley limestone (Lower Permian) of Kansas, some unrecorded horizon and locality in Texas, the Pennsylvanian of Nebraska, the Upper Pennsylvanian (Abo ?) of New Mexico, and the Upper Carboniferous of central European Rus-

sia. The umbilici of all of these forms have been described as being not closed, but those of *S. dumbli* (Hyatt) of Kansas and Texas (?) and *S. tularosense* Miller are small; the nature of the umbilicus of *S. tularosense* at full maturity is not known, and as the umbilicus of the holotype of that species, a moderate-sized specimen, "becomes relatively smaller in the later stages of growth," it may be closed during late maturity. At any rate, the species under consideration seems to be rather close to *S. dumbli* and *S. tularosense*, and it may be closer to the latter than the former. The ventral portion of the conch of *S. rouillieri* (de Koninck) is angular at maturity, and that species does not appear to be particularly close to *S. abundum*. The Texas and Nebraska representatives of *Stenopoceras* have never been described or illustrated and therefore comparisons with them are not possible.

Dr. N. D. Newell of the Kansas Geological Survey recently sent us for comparison an undescribed representative of *Stenopoceras* from the Lower Permian Florena shale of Cowley County, Kansas. In general physiognomy this specimen is closely similar to the Casper form, but apparently it is not conspecific with it. The umbilicus of the Florena specimen is quite small, but although the part of the conch (phragmacone) represented apparently attained a diameter of at least 45 mm., the umbilicus is not closed, and there is no good reason to assume that it was ever closed during ontogenetic development.

Dr. G. H. Girty kindly loaned us for study the specimen from the Casper formation in Gilmore Canyon which he identified in 1908 as "Ammonoid indet." It is a small fragment of a *Stenopoceras*, apparently conspecific with the form we are studying, though preserved in a different type of matrix. Traces of its sutures are discernible and the shape of the ventral and ventro-lateral portions of its conch can be determined quite accurately. The block of limestone in which it is imbedded contains small fragmentary specimens which appear to represent the genera *Pseudorthoceras* and *Metacoceras*.

Occurrence.—Abundant in *Stenopoceras* beds of Casper formation, in Gilmore Canyon, about 8 miles southeast of Laramie, Wyoming; and it occurs at the same locality in the *Meekella* beds of the same formation, about 20 feet above the horizon in the *Stenopoceras* beds at which cephalopods are so abundant.

Syntypes.—Univ. Iowa, nos. 1164–1170.

Genus SOLENOCHILUS Hyatt

SOLENOCHILUS cf. S. BRAMMERI Miller, Dunbar, and Condra

Plate 98, figures 1, 2

We have five specimens from the Casper that are referable to *Solenochilus*. All of these are rather fragmentary and incomplete but they appear to be conspecific. In so far as we have been able to ascertain they do not differ materially from *S. brammeri* Miller, Dunbar, and Condra, but the largest of them, which, however, does not represent the adoral portion of the conch, is considerably smaller than the holotype of that species. Furthermore, the fragmentary nature of our specimens prevents us from referring them definitely to any species. The most nearly complete of the five, which is also the smallest, is here figured.

Conch, which apparently consists of only a very few volutions, is subglobular, nautiliconic, and moderately large. Phragmacone attains a maximum diameter, measured across the umbilicus, of more than 100 mm. Whorls rapidly expanded orad, depressed dorso-ventrally, about half as high as wide, and subrectangular in cross-section though somewhat impressed dorsally. Ventral side of conch is very broadly rounded, ventro-lateral zones are rounded, and lateral sides are nearly straight and almost parallel. On adapical portion of figured specimen dorso-lateral zones of conch are rounded but near mid-length of this

specimen a subangular dorso-lateral keel is developed on the umbilical shoulder, and in the larger specimens this keel becomes very prominent and the umbilical shoulders are flared; the zones immediately ventrad of the umbilical shoulders are then concave. The umbilicus appears to be relatively small, but its diameter can not be ascertained from our specimens.

Test rather thin, and that of specimens somewhat larger than figured specimen is slightly less than 1 mm. thick. Surface of internal mold smooth, and test appears to be marked by only growth-lines. Traces of growth-lines preserved on our specimens indicate that flared umbilical shoulders project slightly forward at apertural margins as low subangular or very narrowly rounded salients, and that there are broad very shallow broadly rounded sinuses along concave zones just ventrad of umbilical shoulders and similar but broader salients along ventro-lateral zones of conch; the course of growth-lines across ventral side of conch can not be ascertained from our specimens.

Camerae are moderate in length, and along venter distance between successive sutures is equal to about one-fourth width of conch. Each suture forms a broad very low broadly rounded ventral lobe and on each side of it there is a similar but somewhat deeper and less broadly rounded ventro-lateral saddle; sutures are nearly straight or only very slightly convex apicad on lateral walls of conch.

Siphuncle small, circular in cross section, ventral and marginal in position, and orthochoanitic in structure. Its diameter is equal to about one-twentieth of the width of conch. Septal necks are about two-fifths as long as camerae, and connecting rings are cylindrical in shape.

Remarks.—The genus *Solenochilus* is known to be widespread in both Europe and North America, and stratigraphically it ranges at least from the Lower Mississippian to the Lower Permian. It does not seem to be abundantly represented at any horizon or any locality, but the majority of the known representatives of it come from the Carboniferous. The similarity of the above-described specimens to the types, particularly the juvenile paratype, of *S. brammeri*, which came from the Upper Pennsylvanian (Kansas City) Argentine limestone of Nebraska, may not be very significant, for none of the known representatives of this genus differ greatly from *S. brammeri*. *S. kentuckiensis* Hyatt of the Lower (?) Pennsylvanian of Edmonson County, Kentucky, also seems to be very similar to it. Many of the described species of *Solenochilus* are based on such fragmentary specimens that adequate comparisons are not possible.

Occurrence.—*Stenopoceras* beds of Casper formation, in Gilmore Canyon, about 8 miles southeast of Laramie, Wyoming.

Figured specimen.—Univ. Iowa, no. 1171.

TRILOBITA

Genus AMEURA J. M. Weller

Plate 96, figures 8, 9

Trilobites are rare in the Casper, and we obtained only three specimens, all of which appear to be conspecific. They are moderately well preserved but they represent only pygidia. The largest of the three, which is rather fragmentary, is about 20 per cent wider than the figured specimen, whereas the smallest specimen is only about three-fourths as large as the one figured.

Dr. J. Marvin Weller has kindly examined our specimens and has written us that they belong to a new genus which is represented by the form commonly identified as *Phillipsia major* Shumard. He further states that our specimens

> most closely resemble a new species . . . from the Luta and Fort Riley limestones of Kansas, but are a little larger and have fewer pleural segments (10 instead of 12).

In regard to the stratigraphic significance of our specimens, Doctor Weller

states that their relatively small number of pleural segments leads him to suspect that they are a little older than the Luta-Fort Riley species, of which the most characteristic part is the glabella, not represented by our specimens. Still, he has no congeneric forms from the uppermost Pennsylvanian, and he, therefore, concludes that he can give us

> no more definite statement than that they [our specimens] are probably either lowermost Permian or uppermost Pennsylvanian.

Occurrence.—*Triticites* beds of Casper formation, in Gilmore Canyon, about 8 miles southeast of Laramie, Wyoming; and lower Casper limestone, near Sybille Springs, 30 miles north of Laramie, Wyoming.

Figured specimen.—Univ. Iowa, no. 1173.

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A. K. MILLER, STATE UNIVERSITY OF IOWA, IOWA CITY, IOWA. H. D. THOMAS, UNIVERSITY OF WYOMING, LARAMIE, WYO. MANUSCRIPT RECEIVED BY THE EDITOR, APRIL 27, 1936.

JOURNAL OF PALEONTOLOGY, VOL. 10, NO. 8, PP. 739–763, PLS. 100–102, DECEMBER, 1936

OSTRACODES OF THE SILICA SHALE, MIDDLE DEVONIAN, OF OHIO

GRACE A. STEWART

ABSTRACT

The lower part of the Silica shale formation has yielded a rich and varied ostracode fauna. In the following paper 39 species are described, 21 of which represent new species or varieties. The species belong in 24 genera, 5 of which are proposed as new. The new genera and the families to which they belong are: *Coelonella* of the Leperditellidae; *Tetrasacculus* of the Primitiidae; *Hamiltonella* and *Lucasella* of the Bairdiidae; and *Menoeidina* of the *Cytherellidae*.

In my previous studies (Stewart, 1927, 1930) on the general fauna of the Silica shale little consideration was given the micro-organisms, as it was recognized that the comprehensive and detailed treatment which they would require was not possible at that time. It now seems advisable to attempt to complete the study of these minute organisms. This paper, which is restricted to a consideration of the ostracodes, is the first to treat specifically of this important element in the fauna. Although rather complete and extensive collections have been made for the study, future collecting will no doubt add many species.

I wish to acknowledge appreciation to A. S. Warthin, Jr., of Vassar College, and H. N. Coryell of Columbia University for helpful suggestions in regard to some of the species. The drawings were made by students employed by the University under the National Youth Administration. Among these I especially wish to thank Charles Lucas and William W. Cummings who are responsible for the major portion of the drawings.

STRATIGRAPHIC AND FAUNAL SUMMARY

When the Silica shale was first studied by me in the quarry of the Sandusky Cement Company at Silica it was considered to comprise a single unit approximately 10 feet in thickness. The shale was underlain at the floor of the quarry by a blue, argillaceous limestone, and overlain by about 4 feet of blue, argillaceous and shaly limestone, which was exposed in the west wall of the quarry. Subsequently data obtained by J. E. Carman from drill records showed that westward in the direction of dip at least 20 feet of blue shale similar to that in the quarry and several feet of limestone, overlies the upper limestone bed of the quarry. At a later date an excavation in the floor of the quarry revealed the blue argillaceous limestone to be a thin, 8-inch layer, below which occurred $2\frac{1}{2}$ feet of blue shale similar to that above. Since this entire sequence from the lowest shale unit exposed in the quarry to the highest argillaceous limestone unit as revealed by the drill represents a repetition of similar lithologic units, Carman proposes to extend application of the term Silica shale to include the entire sequence, a thickness approximating a total of 45 feet. This suggestion seems entirely reasonable from the standpoint of

lithology, although it must be kept in mind that no faunal studies have been made in the upper part of the section west of the quarry.

Of the total thickness of the formation only the basal 16 feet are exposed in the quarry at Silica. The several zones of the formation which are recognized there are as follows:

Zones of the Silica shale in the quarry at Silica, Ohio

	Thickness feet
9. Blue shaly limestone	1.0
8. Blue argillaceous limestone	1.0
7. Blue shale	0.25
6. Blue argillaceous limestone (seaweed zone)	2.0
5. Blue shale	2.5
4. Blue shaly limestone (Bryozoa bed)	0.33
3. Blue shale	6.0
2. Blue argillaceous limestone	0.67
1. Blue shale	2.5

Collections for this study have been made from the lower 14 feet of the formation, chiefly from zones 1, 3, and 5. The zonal distribution of the species, as well as those which occur in the Traverse group of Michigan, is shown in Table 1.

Thirty-nine species have been studied, among which have been recognized such characteristic Middle Devonian forms as *Hamiltonella punctulifera* (Hall), *Amphissites subquadratus* (Ulrich), *Ulrichia conradi* Jones, and *Moorea bicornuta* Ulrich. However, fully half the collection consists of hitherto undescribed forms, for 19 species and 2 varieties are thought to be new forms. In addition, 5 new genera are recognized. The new genera and the families to which they belong are as follows: *Coelonella* of the Leperditellidae, *Tetrasacculus* of the Primitiidae, *Hamiltonella* and *Lucasella* of the Bairdiidae, and *Menoeidina* of the Cytherellidae.

Of the four zones from which collections were made, zone 3 has yielded by far the greatest number of species, 35 of the 39 having been recognized at this horizon. Only 6 species have been collected from zone 6. Since the specimens have come from such a limited stratigraphic range, and since the lithologic character is quite similar throughout the several zones, it is not surprising that no marked changes take place in the faunal assemblage, and that most species range through more than one zone. Although several species, such as *Hamiltonella punctulifera* (Hall), *Halliella bellipuncta* (Van Pelt), *Burlella sublunata* Stewart, n.sp., and *Menoeidina subreniformis* Stewart, n.sp., are represented by an abundance of specimens, others including *Aechmina serrata* Stewart, n.sp., *Moorea bicornuta* Ulrich, *Tetradella cicatricosa* Warthin, and *Tetrasacculus bilobus* Stewart, n.sp., are rare.

The form which occurs in the greatest profusion is the common Middle Devonian species, *Hamiltonella punctulifera* (Hall). It ranges through all the zones but is particularly characteristic of zones 3 and 5. The prevailing type at the base of the shale is the more strongly sculptured form with two spines and a ridge on each valve, whereas near the top of the shale the specimens more commonly have only one spine, and the ridge is less strongly developed. In the Traverse beds of Michigan, according to Warthin (1934, p. 223), the stratigraphically younger speci-

mens of this species have the anterior ridge and spines more strongly developed than the stratigraphically older, which is contrary to the tendency observed in the Silica shale specimens.

Octonaria quadricostata Van Pelt is the most abundant and characteristic species at the top of zone 6, although numerous specimens have been collected from zone 1. It is reported from the Bell shale and Gravel Point stage of the Traverse group.

Halliella bellipuncta (Van Pelt) is

Table I.—Zonal Distribution of Ostracode Species in the Silica Shale and the Traverse Group of Michigan

Species	Silica shale, Ohio				Traverse group of Michigan
	Zone 1	Zone 3	Zone 5	Zone 6	
Aechmina serrata Stewart, n. sp.	X	X	—	—	—
Amphissites subquadratus (Ulrich)	X	X	X	—	X
Amphissites sp.	—	X	—	—	—
Bairdia sp.	—	X	—	—	—
Birdsallella tumida Stewart, n. sp.	—	X	—	—	—
Burlella brevispinata Stewart, n. sp.	—	X	X	?	—
Burlella (?) *bisulcata* Stewart, n. sp.	—	X	—	—	—
Burlella rhomboidalis Stewart, n. sp.	—	X	—	—	—
Burlella (?) *sublunata* Stewart, n. sp.	X	X	X	—	—
Burlella sp.	—	—	—	X	—
Bythocypris indianensis Ulrich	—	X	X	—	—
Bythocypris lucasensis Stewart, n. sp.	—	X	—	—	—
Bythocypris subquadrata Stewart, n. sp.	—	X	—	—	—
Bythocypris sp.	—	X	—	—	—
Coelonella scapha (Stewart)	X	X	—	—	—
Coelonella plana Stewart, n. sp.	—	X	—	—	—
Ctenobolbina trilobata Stewart, n. sp.	X	X	—	—	—
Dizygopleura oblonga Warthin	X	X	X	—	X
Euglyphella sigmoidalis var. *primitiva* Warthin	X	—	X	X	X
Eukloedenella sp.	—	X	X	—	—
Halliella bellipuncta (Van Pelt)	X	—	X	X	X
Hamiltonella ohioensis Stewart, n. sp.	X	X	X	—	—
Hamiltonella ohioensis var. *subcompressa* Stewart, n. var.	—	X	—	—	—
Hamiltonella punctulifera (Hall)	X	X	X	X	X
Haploprimitia simplex Stewart, n. sp.	X	—	X	—	—
Lucasella mundula Stewart, n. sp.	—	X	X	—	—
Lucasella spinulifera Stewart, n. sp.	—	X	X	—	—
Macrocypris acutula Stewart, n. sp.	X	X	X	—	—
Menoeidina subreniformis Stewart, n. sp.	X	X	X	—	—
Menoeidina subreniformis var. *elongata* Stewart, n. var.	X	X	X	—	—
Moorea bicornuta Ulrich	X	—	X	—	X
Octonaria quadricostata Van Pelt	X	—	—	X	X
Poloniella cingulata Warthin	—	X	X	—	X
Primitia seriata Stewart, n. sp.	X	X	—	—	—
Tetradella cicatricosa Warthin	X	X	X	—	X
Tetrasacculus bifidus Stewart, n. sp.	—	X	X	—	—
Tetrasacculus bilobus Stewart, n. sp.	X	X	X	—	—
Ulrichia conradi Jones	—	X	X	—	X
Ulrichia fragilis Warthin	—	X	X	—	X

another common form, and is the most prolific and typical species at the base of zone 1. Warthin (1934, p. 207) states that this species is apparently restricted to the upper one-third of the Traverse beds, although Van Pelt (1933, p. 333) reports it from the Bell shale at the base of the group. If *Halliella bellipuncta* (Van Pelt) is restricted stratigraphically as Warthin has intimated, it follows that the Silica shale might have a position high up in the Traverse.

On the other hand, conflicting evidence for this stratigraphic position of the Silica shale is to be found in the presence of *Poloniella cingulata* Warthin, which Warthin reports to be restricted to the lowest third of the Traverse group. The species has been collected from zones 3 and 5 of the Silica shale, and is abundant in zone 3.

It seems, therefore, that a more detailed knowledge of the stratigraphic range of these species in the Traverse group is necessary before they can be of definite aid in determining the correct stratigraphic position of the Silica shale with reference to the Michigan section.

SYSTEMATIC DESCRIPTIONS

Family LEPERDITELLIDAE Ulrich and Bassler

Genus COELONELLA Stewart, n. gen.

Genoholotype, *Isochilina? scapha* STEWART, *1930*, Ohio Jour. Sci., vol. 30, no. 1, p. 57, pl. 1, figs. 11, 12. Silica shale (Devonian), Sandusky Cement Company quarry, one-half mile north of Silica, Lucas County, Ohio.

Carapace of medium size, subovoid to subquadrate in outline; valves convex, unequal, the right valve larger than the left and overlapping it on the ends and ventral margin; posterior margin depressed along the hinge into an elliptical-shaped sulcus; surface smooth.

This genus resembles *Sansabella* Roundy in having one valve overlapping the other on the ends and ventral margin, and in the channel-like depression along the hinge. It differs, however, in having the right instead of the left the larger and overlapping valve, and in the different shape.

COELONELLA SCAPHA (Stewart)

Plate 100, figures 1, 2

Isochilina (?) *scapha* STEWART, *1930*, Ohio Jour. Sci., vol. 30, no. 1, p. 57, pl. 1, figs. 11, 12.

Carapace of medium size, tumid, subovoid to subquadrate in lateral view; canoe-shaped in dorsal aspect; maximum length midway between ventral and dorsal margins; maximum height in middle of posterior half; maximum thickness midway between the ends. The dimensions of a specimen of average size are: length 1.05 mm.; height 0.63 mm.; thickness 0.55 mm.

Valves very convex in the central area, flattening abruptly towards the ends; right valve larger than left and overlapping it a little on the ends and ventral margin; dorsal margin straight to slightly convex; depressed along the hinge to form a narrow, elliptical sulcus; hinge features not observed; cardinal extremities moderately rounded, the anterior one the more acute of the two; posterior end broadly and evenly rounded, with a fairly noticeable backward swing; anterior end narrowly and uniformly rounded; ventral margin straight to slightly convex, rising forward; surface smooth.

Remarks.—Several perfect specimens of this neat little ostracode have been collected since the species was first described. These additional specimens show

that the right valve overlaps the left except along the channelled portion of the hinge, a feature not previously observed in the holotype. For this reason the species is removed from the genus *Isochilina* where it was provisionally placed, and described as a new genus.

COELONELLA PLANA Stewart, n. sp.

Plate 100, figures 3, 4

Leperditia (?) *subrotunda* (?) STEWART, *1930*, Ohio Jour. Sci., vol. 30, no. 1, p. 57, pl. 1, fig. 10.

Carapace subcircular in lateral aspect; slightly oblique; maximum length slightly below the middle of the shell; maximum height in the posterior half. The dimensions of a complete specimen are: length 0.88 mm.; height 0.70 mm.

Valves moderately convex, the greatest convexity in the central part slightly above the middle, flattening marginally all the way around; right valve larger than left and overlapping it on the ends and ventral margin; dorsal margin straight, channelled along the hinge to form a narrow sulcus; hinge occupying the entire dorsal margin; dentition features not observed; posterior margin broadly and evenly rounded, with little backward swing; anterior margin more narrowly rounded than posterior; ventral margin evenly convex, rising slightly forward; surface smooth.

Remarks.—Since the earlier questionable identification of an incomplete right valve of an ostracode from the Silica shale as *Leperditia*(?) *subrotunda*(?) a complete specimen has been found which demonstrates the relationship of both specimens to the genus *Coelonella*. The species differs from *L. subrotunda* in having the ends more narrowly rounded, and the cardinal extremities more acute. There is no evidence of an eye tubercle. From *Coelonella scapha* the form may be distinguished by the somewhat different shape, the less prominent convexity of the valves, and the conspicuous flattening towards the margins.

Holotype.—Ohio State Univ., no. 18171.

Family PRIMITIIDAE Ulrich and Bassler

Genus HAPLOPRIMITIA Ulrich and Bassler, 1923

HAPLOPRIMITIA SIMPLEX Stewart, n. sp.

Plate 100, figure 5

Carapace small and simple in aspect; oval in outline; greatest length about midway between the dorsal and ventral borders; greatest height in posterior half; greatest thickness in the posterior fourth. The dimensions of a right valve are: length 0.57 mm.; height 0.36 mm.

Valves tumid, equal, the surface rising abruptly from the margins, the posterior end having the steepest slope; dorsal margin almost straight, curving into the regularly rounded ends, of which the anterior is slightly the narrower; ventral margin convex. Hinge line straight; cardinal extremities moderately angular, the posterior being the more acute of the two. Sulcus a simple linear slit, situated a little anterior of the center and extending from the dorsal margin about halfway to the ventral margin. Surface of valves smooth.

Remarks.—The separate valves of this species only have been seen. It is readily recognized by its simple character and narrow linear sulcus. To my knowledge, the genus *Haploprimitia* has not been recognized in the Devonian of North America before.

Holotype.—Ohio State Univ., no. 18172.

Genus PRIMITIA Jones and Holl, 1865

PRIMITIA SERIATA Stewart, n. sp.

Plate 100, figures 6, 7

Shell small, parallelogram-like in lateral view; anterior and posterior essentially the same height. The dimensions are: length 0.67 mm.; height 0.32 mm.

Right valves only observed; convex to tumid, thickest in the anterior half; dorsal margin slightly concave at mid-length; hinge less than the greatest length of the shell; posterior cardinal extremity long and sloping, anterior extremity acute; posterior end evenly

rounded, no distinct backward swing; anterior margin attenuate in dorsal portion, truncate in ventral half; ventral margin gently and evenly convex.

A simple sulcus situated a little posterior to the center is present in the dorsal portion of each valve; entire surface marked by very fine punctations which are arranged so that in some directions they suggest a chain-like pattern.

Remarks.—The material at hand, a few right valves, is scarcely sufficient for either a definite generic or specific determination. The simple characters of the specimens suggest a position in the family Primitiidae, but they are placed in the genus *Primitia* with some reservation because the shape and surface sculpture are not entirely typical of the genus. In the chain-like arrangement of the pits the form resembles *Graphiodactylus* of the family Kirkbyidae, but differs in most other respects.

Syntypes.—Ohio State Univ., no. 18173.

Genus TETRASACCULUS Stewart, n. gen.

Genotype, *Tetrasacculus bilobus* Stewart, n. sp., Silica shale (Devonian), Silica, Ohio.

Carapace small to medium in size; equivalved; subquadrate to subovoid in lateral view; hinge line straight and occupying the entire length of the dorsal margin; sulcus linear and curved, simple or bifurcating, centrally or somewhat posteriorly placed; nodes may or may not be present on either side of the sulcus; female with four pairs of large, spherical brood pits or swellings along the posterior and ventral margins; ventral spine may be present in posterior lobe of male; surface finely reticulate or pustulose.

The characteristics of this genus suggest a position midway between *Euprimitia* and *Primitia*, from both of which it differs in the presence of brood pits in the female along the lower posterior and ventral margins. It does not have the elevated false border around the free edge of the valve as in *Euprimitia*,

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EXPLANATION OF PLATE 100

All types of new species are in the Geological Museum, Ohio State University, Columbus, Ohio.

FIGS. *1, 2*—*Coelonella scapha* (Stewart). Left valve and hinge views of same specimen, ×29. Zone 3. (p. 742)

3, 4—*Coelonella plana* Stewart, n. sp. Left valve and hinge views of holotype, ×29. Zone 3. (p. 743)

5—*Haploprimitia simplex* Stewart, n. sp. Right valve of holotype, ×50. Zone 1. (p. 743)

6, 7—*Primitia seriata* Stewart, n. sp. Exterior and interior views of right valves of two syntypes, ×29. Zone 3. (p. 743)

8–11—*Tetrasacculus bilobus* Stewart, n. sp. *8, 9*, Hinge and left valve views of male, syntype, ×46. *10, 11*, Left valve and ventral view of female, syntype, ×46. Zone 3. (p. 745)

12–14—*Tetrasacculus bifidus* Stewart, n. sp. *12*, Left valve view of female, syntype, ×29. Zone 3. *13, 14*, Right valve and hinge views of male, syntype, 46. Zone 5. (p. 745)

15, 16—*Halliella bellipuncta* (Van Pelt). Exterior right valve and interior left valve views, ×46. Zone 1. (p. 746)

17, 18—*Ulrichia conradi* Jones. Right valve and hinge views of two different specimens, ×33. Zone 3. (p. 747)

19, 20—*Ulrichia fragilis* Warthin. Hinge and right valve views of typical specimen, ×42. Zone 3. (p. 747)

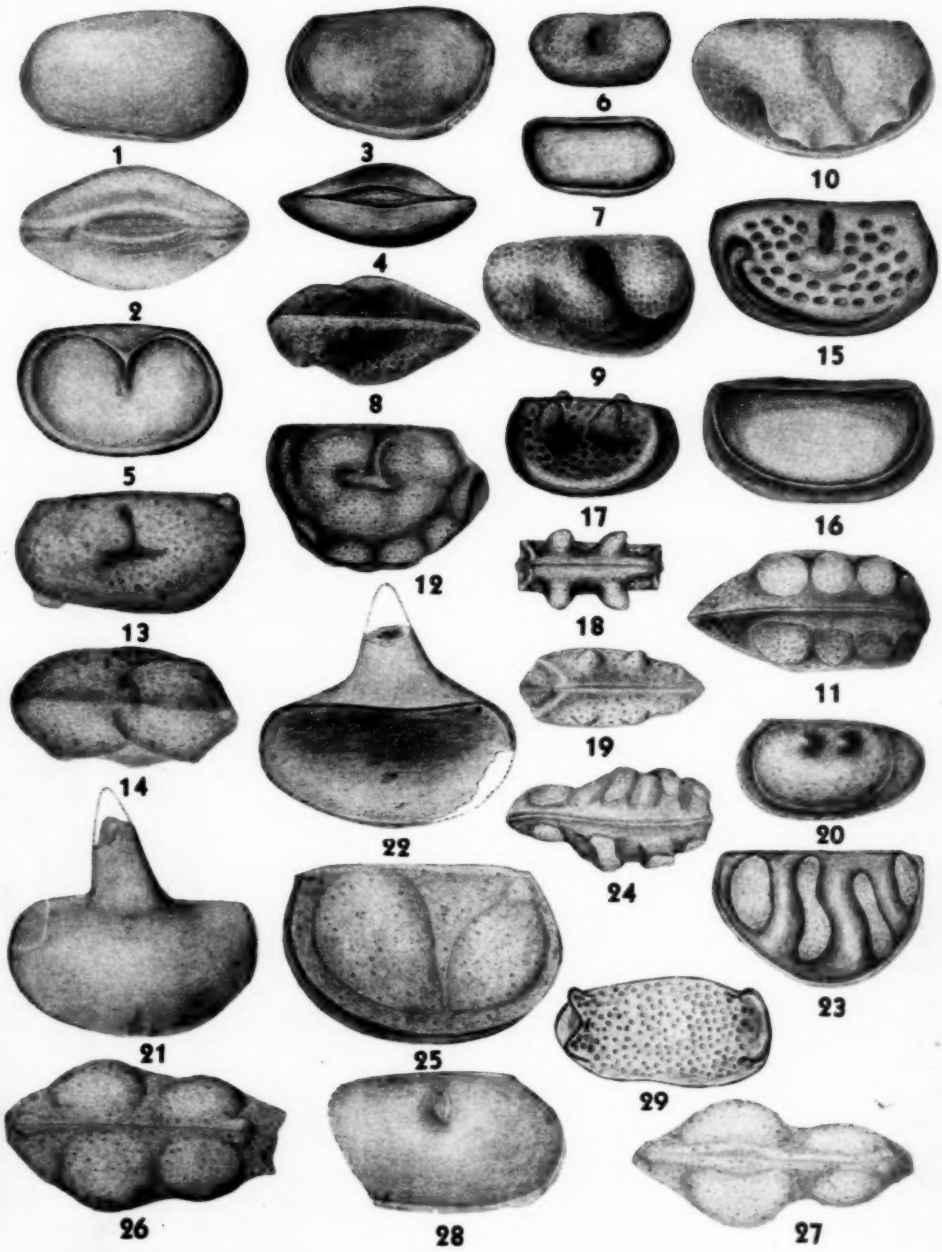
21, 22—*Aechmina serrata* Stewart, n. sp. Exterior view of left valve and interior view of right valve, syntypes, ×46. Zone 3. (p. 748)

23, 24—*Tetradella cicatricosa* Warthin. Left valve and ventral views of male specimen, ×29. Zone 3. (p. 748)

25–27—*Ctenobolbina trilobata* Stewart, n. sp. *25, 27*, Left valve and hinge views of male, syntype, ×29. *26*, Hinge view of female, syntype, ×29. Zone 3. (p. 749)

28—*Eukloedenella* sp. Left valve, ×29. Zone 3. (p. 750)

29—*Moorea bicornuta* Ulrich. Left valve view of typical specimen, ×25. Zone 1. (p. 752)



Stewart, Middle Devonian Ostracodes

UNIV. OF MICH.

and the shape is different from most of the species of *Primitia*.

TETRASACCULUS BILOBUS Stewart, n. sp.

Plate 100, figures 8–11

Carapace small, the female larger than the male; subquadrate to subovoid in lateral view; awl-shaped in dorsal aspect; maximum length a little above the middle of the shell; maximum height in the middle of the posterior half; maximum thickness in the mid-ventral region of the male, and in the post-ventral region of the female. The dimensions of a female specimen are: length 0.70 mm.; height 0.34 mm.; thickness 0.34 mm. The dimensions of a male specimen are: length 0.63 mm.; height 0.32 mm.; thickness 0.29 mm.

Valves equal, moderately convex to tumid; dorsal margin straight, the valves meeting with a slight linear depression along the hinge; cardinal extremities angular, the posterior the more acute of the two; posterior end broadly and evenly rounded, with a distinct backward swing; anterior end narrowly rounded, with a slight acumination above mid-height; ventral margin convex, rising forward.

Each valve marked by a simple, curved sulcus, beginning a little below the dorsal margin and somewhat posterior of the middle, and swinging backward toward the post-ventral angle, dividing each valve into a small, lower posterior lobe, and a larger, more convex anterior lobe which includes about two-thirds of the valve; surface of valves appreciably depressed in the antero-ventral portion. In the male specimens the ventral portion of the posterior lobe is extended into a short spine pointing backward, and a faint carina parallels both the posterior and ventral margins to about one-fourth the distance from the anterior end. In the female specimens four large pairs of spherical brood pits extend from the middle of the posterior margin along the ventral margin to about one-third the distance from the anterior end. Surface of valve in both male and female finely reticulate.

Remarks.—This interesting little form does not appear to be closely related to any described species. In the preliminary study the male and female specimens were not recognized as being the same species, until it was realized that apart from the brood pits in the female, the outline and surface sculpture were identical. In the arrangement of the brood pits the form resembles *Tetradella cicatricosa* Warthin, but that form has six pairs of brood pits instead of four, and the surface sculpture is entirely different.

Syntypes.—Ohio State Univ., no. 18174.

TETRASACCULUS BIFIDUS Stewart, n. sp.

Plate 100, figures 12–14

Carapace of medium size, the female larger than the male, subrhomboidal to subquadrate in lateral view; maximum length a little above the middle of the shell; maximum height approximately midway between the ends in female specimens, and in the anterior fourth in male specimens; maximum thickness in the anterior half. The dimensions of a male specimen are: length 0.67 mm.; height 0.36 mm. The dimensions of a female specimen are: length 0.97 mm.; height 0.59 mm.

Valves convex, in some cases tumid, equal; dorsal margin smooth and straight, the hinge line less than the greatest length of the shell; articulation features not positively identified, although the separate valves have been observed; cardinal extremities angular, the anterior the more acute of the two; posterior margin with pronounced backward swing; anterior margin acuminate in upper part; ventral margin convex. In females the free margins are considerably swollen by four pairs of brood pits which extend from the mid-posterior margin to the anterior end of the ventral margin. In males, the post-ventral margin expands into a broad, finlike protuberance. In both males and females each valve is marked in the mid-dorsal

region by an elongate well-defined sulcus, which becomes bifid midway to the ventral border; the posterior branch curves around the posterior node reaching almost to the dorsal margin in male specimens, but less extended in the females; the anterior branch extends only around the ventral side of the anterior node in both sexes; nodes large, low, and quite distinct, about equal in size; entire surface of valves, including the nodes, finely pustulose.

Remarks.—This species is placed in the same genus as *Tetrasacculus bilobus* because of the similarity in the arrangement and number of brood pouches in the female. The sulcus, however, is entirely different, and the low swellings or nodes on both sides of it suggest a much closer relationship to the genus *Primitia* than does that species. It might be desirable ultimately to erect a new generic term for this form, but for the present it seems best to assign it to *Tetrasacculus*.

Syntypes.—Ohio State Univ., no. 18175.

Genus HALLIELLA Ulrich, 1891

HALLIELLA BELLIPUNCTA (Van Pelt)

Plate 100, figures 15, 16

Amphissites bellipunctus VAN PELT, *1933*, Jour. Paleontology, vol. 7, no. 3, p. 332, pl. 39, figs. 37–40.

Halliella bellipuncta WARTHIN, *1934*, Mus. Paleontology, Univ. Mich., Contr., vol. 4, no. 12, p. 208, pl. 1, fig. 2.

Carapace of medium size, subquadrate to subovate in lateral view; length nearly twice as great as the height; maximum length about midway between the dorsal and the ventral margins; place of maximum height somewhat variable, but in most specimens essentially midway between the ends; maximum thickness in postero-ventral quarter. The dimensions of an adult specimen of average size are: length 0.67 mm.; height 0.36 mm.

Valves depressed convex, essentially equal, although accurate observation of this feature is not possible because the valves have not been found in articulation; ventrally the margin of the right valve fits into a shallow groove on the left valve; dorsally the posterior and anterior portions of the left valve are fitted with shallow grooves into which the edge of the right valve is inserted. Dorsal margin slightly concave centrally, the hinge less than the greatest length of the shell. Cardinal angles distinct, the posterior more acute than the anterior.

Ends subequally rounded, the anterior more even in contour than the posterior; ventral margin evenly convex to slightly flattened, rising a little backward.

Each valve marked by an elongate, rather deeply impressed sulcus situated a little anterior to the center, and extending from a little above mid-height almost to the dorsal margin. Ventrad of the pit the shell is swollen into a distinct ridge paralleling the ventral and posterior margins, and extending from the antero-ventral region to midway between the dorsal and ventral margins on the posterior where it terminates in a blunt knob. This ridge is separated from the margin of the shell by a distinct groove which roughly parallels it.

Surface of valves, with the exception of the marginal areas, covered with coarse subcircular pits, forming a reticulate pattern. Occasionally the pits are uniformly arranged so that a striated instead of a reticulate pattern is produced.

Remarks.—This species is represented in our collections by a number of individual valves, no entire carapace having come under observation. The specimens concur in every detail with the type specimens of the species, which are in Walker Museum at the University of Chicago. However, the Silica shale specimens show additional articulation features which the Bell shale examples lack. Warthin's description and illustrations of this species differ from both the types and the Silica shale specimens in having the ventral ridge straight and parallel to the dorsal margin instead of curving and parallel to the ventral margin. In addition he orients the carapace in the opposite direction to our interpretation.

Genus ULRICHIA Jones, 1890

ULRICHIA CONRADI Jones

Plate 100, figures 17, 18

Ulrichia conradi JONES, *1890*, Geol. Soc. London, Quart. Jour., vol. 46, p. 544, fig. 2.—WARTHIN, *1934*, Mus. Paleontology, Univ. Mich., Contr., vol. 4, no. 12, p. 213, pl. 1, fig. 10.

Carapace subquadrate viewed laterally, posterior end scarcely higher than anterior, the greatest height being a little posterior to the center of the valves. Proportion of length to height approximately as 2 to 1. Length 1.00 mm., height 0.50 mm.

Valves depressed, essentially the same thickness throughout the entire length. Hinge line straight, approximately equal to the greatest length of the shell; cardinal extremities angular; posterior and anterior ends evenly rounded; ventral margin convex, rising slightly anteriorly; free margins elevated into a conspicuous marginal ridge.

Two large tubercles, rising slightly above the dorsal margin, are present on the dorsal portion of each valve, the anterior tubercle being somewhat more protuberant than the posterior; posterior tubercle in some specimens larger and blunter than the anterior, the latter usually directed obliquely forward. Kirkbyan pit not observed on specimens examined.

The surface of each valve, except for the flat border and the tubercles, is rendered reticulate by small pits which are remarkably uniform in size.

Remarks.—A few examples of this neat little ostracode have been collected from the Silica shale. The specimens do not appear to depart in their general characters from the typical species as it occurs elsewhere.

ULRICHIA FRAGILIS Warthin

Plate 100, figures 19, 20

Ulrichia fragilis WARTHIN, *1934*, Mus. Paleontology, Univ. Mich., Contr., vol. 4, no. 12, p. 213, pl. 1, fig. 2.

Carapace small, elongate-oval viewed laterally; greatest height in middle of posterior half; greatest length about midway between dorsal and ventral margins. Length 0.60 mm.; height 0.35 mm.

Viewed marginally valves gently convex, thickest in middle of posterior half; hinge line straight, about three-fourths of the greatest length of the shell; cardinal extremities obtusely angular, the posterior one the more acute of the two; posterior margin evenly rounded, with pronounced backward swing; anterior margin somewhat attenuate; ventral margin convex, rising noticeably forward; false border marked by a semicircular ridge beginning at the dorsal margin and approximately paralleling the posterior and ventral margins, but cutting obliquely across the anterior end about one-fifth the distance from the end; scarcely reaching the dorsal margin anteriorly.

Two short, blunt tubercles, of about the same strength, are medially situated just below the dorsal margin. Kirkbyan pit scarcely larger than a reticulation pit, situated a little post-ventral of the posterior tubercle. Entire surface of valves finely reticulate.

Remarks.—The few specimens which the writer has collected are proportionately a little longer than the specimen figured by Warthin, and in addition the anterior portion outside of the false border is reticulate as well as the rest of the surface. In a collection of ostracodes made by Warthin from the Silica shale, he has identified three specimens with this species, two of which appear to be quite typical, but the third agrees with my specimens in the greater length and reticulate anterior. Since due allowance should be made for differences in perfection of preservation of these minute surface characters, it seems highly probable that all the specimens should be included in the same species.

Genus AECHMINA Jones and Holl, 1869

AECHMINA SERRATA Stewart, n. sp.

Plate 100, figures 21, 22

Shell small, symmetrical, subovate or semi-circular in outline; surface of valves evenly convex; greatest height in approximately the center; greatest thickness about midway between dorsal and ventral margins. Length 0.70 mm.; height 0.36 mm.

Dorsal margin slightly concave at mid-length, the hinge line somewhat less than the greatest length of the shell; cardinal extremities angular, the posterior more acute than the anterior; both ends evenly rounded, the posterior with scarcely any perceptible backward swing; ventral margin uniformly convex. Free margins marked by a very narrow, finely denticulate rim.

Spine large and fairly long, wide at the base and tapering abruptly to the apex, situated in the mid-dorsal region slightly posterior to the center; directed anteriorly. Surface of valves smooth.

Remarks.—A few separate valves have come under my observation. Difficulty was experienced in orienting the valves because of the slight difference between the two ends. The position of the spine, which is a little off center, was the criterion finally decided upon as being the most reliable. The upper part of the spine in all specimens is broken away. A general agreement of *A. serrata* and *A. marginata* Ulrich from the Hamilton shale of Eighteen-mile Creek, New York, may be noted. However, that species has a longer and distinctly more slender spine than the Silica shale form, and lacks the marginal teeth. Considering the extremely minute and fragile character of the marginal teeth, they may have been present originally on *A. marginata* and were not sufficiently well preserved to be recognized.

A. serrata also resembles *A. cuspidata* Jones and Holl quite closely, but the spine is shorter and broader at the base and the outline is more regularly hemispherical.

Syntypes.—Ohio State Univ., no. 18179.

Family BEYRICHIIDAE Jones

Genus TETRADELLA Ulrich, 1891

TETRADELLA CICATRICOSA Warthin

Plate 100, figures 23, 24

Tetradella cicatricosa WARTHIN, *1934*, Mus. Paleontology, Univ. Mich., Contr., vol. 4, no. 12, p. 209, pl. 1, figs. 4–6, Thunder Bay series, Michigan.

Warthin describes this species as follows:

> Carapace semiovate in lateral view, with pronounced backward swing; greatest height one-third of length from posterior end; both ends make distinct, slightly obtuse angles with the hinge line; hinge line straight (convex in adult females), nearly the greatest length of the shell; well-preserved adults show about seventy fine denticulations on the hinge and rarely some on the free margins; free margins surrounded by a narrow false border; in females the false border is swollen from the anterior node to the post-cardinal angle, incorporating the lower ends of the three posterior nodes, and containing six brood pits; each valve is crossed transversely by four ridgelike nodes; the anterior node is low and subelliptical; the other nodes are narrow and higher, the one next to the anterior being the strongest; in males the lower ends of the two inner nodes project below the ventral margin; the outer surface of the nodes (except the posterior node in females) is pustulose, the pustulose areas being surrounded by a distinct border; a short fimbriate keel borders the anterior end of the right valve; right valve grooved on free margins to receive the edge of the left valve. Length, 1.04 mm.; height, 0.59 mm.; thickness, 0.61 mm.

Remarks.—A few adult female specimens and a young male have been collected from the Silica shale. The adult females agree in every respect with Warthin's diagnosis of the species. The young male specimen, however, shows characters so different from the female that at first I was inclined to place it in a

different species. The characters are, however, essentially those of the male as recognized by Warthin, and there seems to be little question about its correct position in this species.

The young specimen differs from the adult in the proportionately greater length with respect to the height, the more attenuate anterior end, and the longer hinge. The narrow false border surrounding the free margin, which is characteristic of the species, appears to be obsolete, and the four nodes evidently do not unite ventrally. If Warthin's species is placed correctly in the genus *Tetradella*, of which there is considerable question, the union of the four nodes below is not a significant feature of the young of this genus, although I consider it to be a distinctive feature of the adult. The anterior lobe is proportionately lower than in the adult. The two central ridges, of which the anterior is the stronger, project slightly beyond the margin of the valves.

Genus CTENOBOLBINA Ulrich
1908, emend.

CTENOBOLBINA TRILOBATA Stewart, n. sp.

Plate 100, figures 25–27

Carapace quite large, robust, subquadrate in lateral view; greatest length about midway between the dorsal and ventral margins; greatest height just posterior to center of shell. Relation of length to height as 3 to 2. Length (exclusive of frill) 1.50 mm.; height 1.00 mm.

Dorsal margin straight, the hinge a little less than the greatest length of the shell; articulation characters not observed; cardinal extremities angular, the posterior more obtuse than the anterior; posterior margin with pronounced backward swing; ventral margin convex, rising anteriorly; anterior margin evenly convex; a conspicuous ridge or false border extending into a distinct frill parallels the free margins.

Median sulcus deeply impressed, curving backwards, and extending ventrally from a little posterior of the center of the dorsal margin to within a short distance of the false border; in females due to the swollen connection between the anterior and posterior lobes the sulcus fades out some distance above the ventral margin; a slight sulcus is present in the dorsal portion of the anterior lobe, which gives in dorsal view a distinctly tri-lobed appearance to the valves. Anterior lobe decidedly bulbous, much thicker than posterior lobe; in females the posterior lobe is thicker than in the males. A small bulbous swelling is present just beneath the post-dorsal angle of each valve in all the specimens studied.

Entire surface of carapace granulose or papillose in character.

Remarks.—A few specimens, which are here described as a new species, seem to fit the general requirements of the genus *Ctenobolbina* although there are some differences which should not be overlooked. The correct orientation of the specimens has caused me some concern. The criteria which seem most useful are the backward swing of one end (the posterior) and the rising of the ventral margin at the other end (the anterior). That the anterior half is much thicker than the posterior, although contrary to the typical species of the genus, suggests an affiliation with the *C. subcrassa* group which may have the anterior end thicker than the posterior. However, the surface ornamentation is more characteristic of the *C. ciliata* group which is characterized by the bulb-like form of the posterior lobe. In the presence of the small lobe below the post-dorsal angle the specimens resemble neither species.

In the papillose surface features *C. trilobata* resembles *C. papillosa* (Devonian Bryozoa bed, Falls of the Ohio), but the thick anterior lobe and the post-dorsal bulb distinguish it readily from that species.

The greater thickness of the carapace, especially in the posterior lobe, distinguishes the female from the male, as does also the decidedly wider confluence of the two lobes.

Only remnants of the frill adhere to the rim of the false keel, so that its true character cannot be definitely determined.

Syntypes.—Ohio State Univ., no. 18181.

Family KLOEDENELLIDAE Ulrich and Bassler

Genus EUKLOEDENELLA Ulrich and Bassler, 1923

EUKLOEDENELLA sp.

Plate 100, figure 28

A single imperfect specimen has been examined which agrees in its essential characters with the above genus. The shape and true dimensions are not definitely known because the anterior end is missing. The valves are moderately and evenly convex. A simple sulcus occurs on each valve just below the dorsal margin, a little posterior of the center.

The specimen is not sufficiently complete for specific identification. It evidently belongs in Group II of the genus *Eukloedenella* as outlined by Ulrich and Bassler.

Genus DIZYGOPLEURA Ulrich and Bassler, 1923

DIZYGOPLEURA OBLONGA Warthin

Plate 101, figures 1–4

Dizygopleura oblonga WARTHIN, *1934*, Mus. Paleontology, Univ. Mich., Contr., vol. 4, no. 12, p. 211, pl. 1, fig. 8.

Carapace transversely oval in outline; approximately twice as long as high; highest posteriorly, the greatest height in the posterior third. Length of average adult 1.20 mm.; height (measured posteriorly) 0.65 mm. Carapace thickest in anterior portion, in females quite tumid in this region.

Dorsal margin straight or slightly undulating, rounding off with little evidence of angularity to the ends of the carapace of which the posterior end is the more symmetrically rounded, the anterior being somewhat attenuate. Articulation characters of hinge not determinable on specimens examined. Ventral edge emarginate in the central portion.

Valves unequal, the right valve somewhat larger than the left, overlapping it all the way around, the overlap being least conspicuous along the hinge.

Lobation of valves distinct; sulci deeply impressed; posterior sulcus begins almost at the dorsal margin, curves abruptly forward near the ventral margin, and terminates about one-fourth the distance from the posterior end of the valve; median sulcus shorter and broader in proportion, beginning at about the same distance below the hinge as the posterior sulcus, but terminating about the middle of the valve, curving slightly backward; anterior sulcus begins further below the dorsal margin than the other two, complementing the curve of the posterior sulcus ventrally, the space between the ventral terminations of the posterior and anterior sulci being equal to about one-third the length of the valves. The two median lobes, therefore, are joined ventrally. The anterior lobe, particularly in females, is elevated into a conspicuous ridge, curving forward.

Remarks.—In their original discussion of *Dizygopleura*, Ulrich and Bassler divided the numerous species belonging to it into five groups for greater ease of comparison. *D. oblonga* Warthin falls in group IV, which has for its typical species the Silurian form and genotype *D. swartzi* Ulrich and Bassler. This group is characterized by the distinct quadrate lobation, thick valves, and long, narrow, deeply impressed anterior and posterior sulci.

D. oblonga Warthin resembles *D. swartzi* Ulrich and Bassler in its general characters, but differs in the greater prominence of the anterior node, the greater extension of the posterior end, and the less inclination to angularity of the cardinal angles. In the same respects it differs from *D. halli* (Jones), and in addition the anterior and posterior sulci extend further into the central portion of the valve ventrally.

D. oblonga Warthin is very similar to *D. trisinuata* Van Pelt and may be a

synonym. That form is more elongate and the ratio of its length to its height is 3 to 1 instead of 2 to 1 as in the species under discussion. Its outline appears to be less symmetrically oval than *D. oblonga* Warthin.

Family KIRKBYIDAE Jones

Genus AMPHISSITES Girty, 1910

AMPHISSITES SUBQUADRATUS (Ulrich)

Plate 101, figures 5, 6

Kirkbya subquadrata ULRICH, *1891*, Cincinnati Soc. Nat. History, Jour., vol. 13, p. 192, pl. 15, fig. 1, Devonian Bryozoa bed, Falls of the Ohio.

Amphissites diadematus VAN PELT, *1932*, Jour. Paleontology, vol. 7, pp. 329–331, pl. 39, figs. 8–15, Bell shale, Middle Devonian, Michigan.

Carapace subquadrate viewed laterally; transverse, higher posteriorly. Greatest height about one-fourth the distance from the posterior end. Length of average adult 1.00 mm., maximum height measured posteriorly 0.75 mm., thickest in posterior portion. Valves meet evenly along dorsal margin, which is smooth and straight; articulation by means of a single tooth beneath cardinal angle of left valve which fits into socket on the right (not distinctly observed in specimens studied). Valves essentially equal. Cardinal angles obtuse. Free margins generally smooth or with fine reticulations parallel to edge. Ventral margin straight or very slightly concave at mid-center.

A conspicuous ridge or carina encircles each valve, approximately paralleling the ventral border, but curving sharply upward and inward at each end and extending to the dorsal margin. This ridge produces the subquadrate outline for which the species is named, and when viewed ventrally gives a flattened appearance to the shell. Post-ventral of the kirkbyan pit, a slightly developed, second carina, paralleling the ventral portion of the keel and extending along its entire length is sometimes present on adult specimens.

The surface is ornamented by rather regularly arranged polygonal reticulations. On older and more rotund specimens the sides of the reticulations seem to be strengthened in certain directions so that a striated, instead of a reticulated effect, is produced. These striations are often pronounced enough to be called carinations. Post-ventral of the kirkbyan pit these strengthened lines approximately parallel the ventral margin, but post-dorsal of it they tend to radiate to the dorsal margin.

Kirkbyan pit equal to about three times the size of a reticulation, oval to almost round in shape, situated slightly anterior to the center, evidently not oriented in any particular way.

Remarks.—An abundance of well-preserved specimens of this species has been collected from the Silica shale. Although the internal characters cannot usually be observed the external ones are preserved in fine detail, and agree in all essentials with typical examples of the species from the Falls of the Ohio. Adult specimens are generally much more convex than young specimens, and the striated effect of the surface sculpture is much more pronounced. I have examined the types of *A. diadematus* Van Pelt in the collections at Walker Museum, University of Chicago, and although there are some slight variations in surface sculpture and in degree of development of carina from *A. subquadratus* (Ulrich) I feel that these are not sufficient to justify separation into a different species.

AMPHISSITES sp.

One valve of a very small specimen has the essential characters of the genus *Amphissites*. It is reniform in shape, and has the reticulate surface and well-developed false keel as in *A. subquadratus* Ulrich. The ends are evenly rounded, the ventral margin convex and the dorsal slightly concave. The false keel is more prominent at the ends. Additional material may justify the recognition of this form as a new species.

Family YOUNGIELLIDAE Kellett

Genus MOOREA Jones and Kirkby, 1867

MOOREA BICORNUTA Ulrich

Plate 100, figure 29

Moorea bicornuta ULRICH, *1891*, Cincinnati Soc. Nat. History, Jour., vol. 13, p. 191 pl., 16, figs. 4*a–c*.

Carapace subquadrangular to elliptical in outline. A specimen of average size measures: maximum length 0.84 mm., midway between the dorsal and ventral margins; maximum height 0.42 mm., measured in the middle of the posterior half; maximum thickness 0.29 mm., measured approximately midway between the ends.

Dorsal margin nearly straight, sloping obliquely forward from the middle of the posterior half, and curving into the somewhat narrowly rounded anterior margin; posterior end evenly and more broadly rounded than the anterior; ventral margin straight or slightly concave at mid-length. Hinge line straight, oblique; articulation features not definitely determined.

Valves gently convex, the right a little the larger of the two, and overlapping the left slightly along the ventral margin.

Two large, blunt, flattened spines, curving obliquely forward from the surface of the shell, are present on each valve at the anterior end; those on the left valve are slightly larger and flatter than those on the right. A prominent concentric ridge curving obliquely backward parallels the posterior margin of each valve.

Surface of both valves finely reticulate.

Remarks.—A few specimens have the general characteristics of the species apart from the fact that the anterior spines appear to be larger and blunter than in the specimen figured by Ulrich. The type of the species has not been available for study.

Family THLIPSURIDAE Jones

Genus OCTONARIA Jones, 1887

OCTONARIA QUADRICOSTATA Van Pelt

Plate 101, figures 7–9

Octonaria quadricostata VAN PELT, *1933*, Jour. Paleontology, vol. 7, p. 336, pl. 39, figs. 41–51, Bell shale, Middle Devonian, Michigan.

EXPLANATION OF PLATE 101

All types of new species are in the Geological Museum, Ohio State University, Columbus, Ohio.

FIGS. *1–4—Dizygopleura oblonga* Warthin. *1*, Right valve of male, ×29. *2*, *3*, Left valve and hinge views of female, ×29. *4*, Right valve of young male specimen, ×46. Zone 3. (p. 750)

5, *6—Amphissites subquadratus* (Ulrich). Right valve and hinge views, ×37.5. Zone 3. (p. 751)

7–9—Octonaria quadricostata Van Pelt. *7*, Left valve view, ×33. *8*, Interior right valve, ×33. *9*, Right valve view, ×33. Zone 1. (p. 752)

10–12—Poloniella cingulata Warthin. *10*, Right valve of male specimen, ×33. *11*, Left valve of female specimen, ×33. *12*, Right valve of young male, ×33. Zone 3. (p. 753)

13, *14—Euglyphella sigmoidalis* var. *primitiva* Warthin. Exterior and interior views of right valve, ×33. Zone 1. (p. 754)

15—Bairdia sp. Right valve, ×29. Zone 3. (p. 754)

16—Bythocypris indianensis Ulrich. Right valve, ×29. Zone 3. (p. 755)

17—Bythocypris lucasensis Stewart, n. sp. Right valve, holotype, ×29. Zone 3. (p. 755)

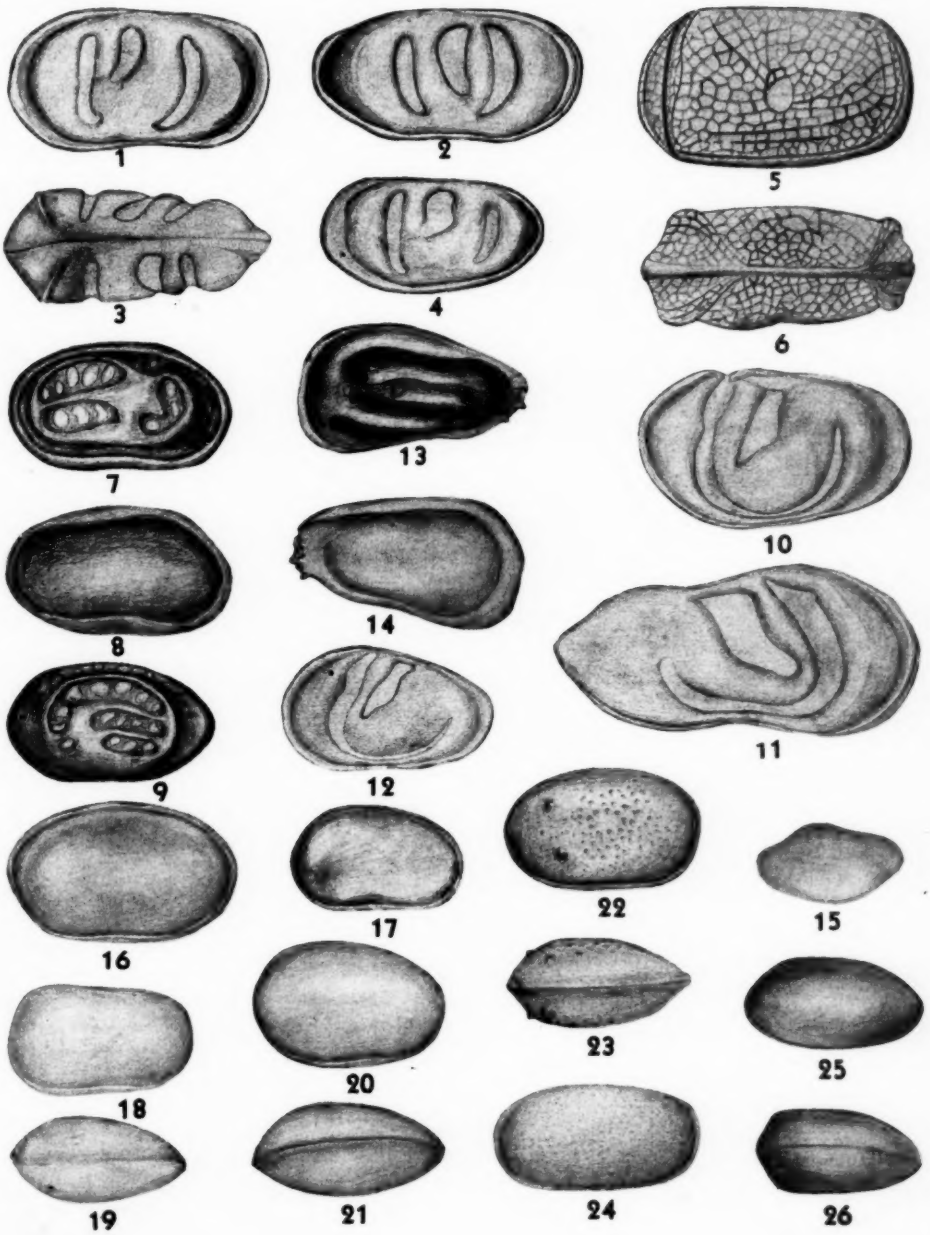
18, *19—Bythocypris subquadrata* Stewart, n. sp. *18*, Right valve view, syntype. *19*, Hinge view, syntype, ×33. Zone 3. (p. 755)

20, *21—Bythocypris* sp. *20*, Right valve view, ×29. *21*, Hinge view, ×29. Zone 3. (p. 756)

22, *23—Hamiltonella ohioensis* Stewart, n. sp. Right valve and hinge views of syntypes, ×29. Zone 3. (p. 757)

24—Hamiltonella ohioensis var. *subcompressa* Stewart, n. var. Right valve view of holotype, ×29. Zone 3. (p. 758)

25, *26—Macrocypris acutula* Stewart, n. sp. Left valve and hinge views of syntypes, ×29. Zone 3. (p. 758)



Stewart, Middle Devonian Ostracodes

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Carapace subrhomboidal in lateral view, tumid; longer than high; greatest length approximately midway between the dorsal and ventral margins; greatest height slightly posterior to the center; maximum thickness in middle of anterior half at edge of ridge. The dimensions are: length 0.90 mm.; height 0.56 mm.; thickness 0.52 mm.

Dorsal margin convex, curving more abruptly to the posterior end than the anterior; ends unequally rounded; ventral margin slightly concave at mid-length; hinge line straight, scarcely more than one-half the length of the dorsal margin, sloping posteriorly; valves thick somewhat flattened, the right the larger of the two and overlapping the left, the greatest overlap along the ventral margin; margin of right valve grooved for the reception of the edge of the left valve.

The surface of both valves rises abruptly plateau-like from the margins, the steeply inclined border is smooth or finely striated, while the elevated surface is sculptured by numerous pits and ridges, which are different on the two valves. Each valve has a transverse ridge just posterior to the center, which stretches across the summit of the plateau from dorsal to ventral margin. On the left valve a longitudinal ridge is connected with the middle portion of transverse ridge and curves toward the antero-ventral angle of the plateau; ventrad of this ridge cross bars dissect the surface into three pits; dorsad of the bar the number of pits appears to be variable, but usually five are present; posterior to the transverse cross bar a shorter longitudinal ridge curves toward the postero-ventral angle of the plateau; ventrad of this ridge one deep pit occurs, and dorsad of it are two pits. On the right valve two longitudinal ridges extend anteriorly from the transverse ridge; three parallel rows of pits are developed in the intervening depressions between the ridges and the edge of the platform; a fourth row of pits occurs along the dorsal border between the edge of the plateau and the margin; small indistinct pits occur on the dorsal portion of both ends; posterior of the transverse ridge the cross-hatching is irregular, and usually three distinct pits are developed.

Remarks.—This unique species is represented in our collections by both entire specimens and separate valves. The distinct surface sculpture readily separates it from associated forms. It occurs characteristically at the top of zone 6, and is perhaps the most distinct fossil of this zone.

Genus POLONIELLA Gurich, 1896

POLONIELLA CINGULATA Warthin

Plate 101, figures 10–12

Poloniella cingulata WARTHIN, *1934*, Mus. Paleontology, Univ. Mich., Contr., vol. 4, no. 12, p. 212, pl. 1, fig. 9, Traverse group, Michigan.

Carapace obliquely ovoid in lateral view, highest in the posterior half. Length of average adult 1.10 mm., height (measured posteriorly) 0.80 mm. Large specimens, which possibly are females of the species, measure length 1.60 mm., height 0.90 mm. Carapace thickest in middle of anterior half.

Dorsal margin straight or slightly undulating, oblique, the hinge notched posteriorly by a large hinge tooth; cardinal angles obtuse; posterior margin broadly and symmetrically rounded; anterior margin attenuate; ventral margin essentially straight, but in most individuals slightly emarginate at mid-length, rising anteriorly.

Lobation of valves distinct; sulci deeply impressed, and dividing each valve into four unequal nodes; posterior sulcus begins at the hinge tooth, curves slightly posteriorly, is broad dorsally but ventrally becomes narrow and curves forward to merge with the anterior sulcus; median sulcus broad, triangular in outline, beginning just below the hinge, extending ventro-posteriorly to about two-thirds the distance from the dorsal margin; anterior sulcus the least well defined of the three, beginning about mid-

way between dorsal and ventral margins, thus dividing the anterior lobe only in the lower portion.

Remarks.—This beautiful little form is abundantly represented in the Silica shale and is particularly characteristic of zones 3 and 5. It can readily be separated from the associated *Dizygopleura oblonga* Warthin because of the different shape and the union of the anterior and posterior sulci.

Genus EUGLYPHELLA Warthin, 1934

EUGLYPHELLA SIGMOIDALIS var. PRIMITIVA Warthin

Plate 101, figures 13, 14

Euglyphella sigmoidalis var. *primitiva* WARTHIN, *1934*, Mus. Paleontology, Univ. Mich., Contr., vol. 4, no. 12, p. 221, pl. 1, fig. 22, Traverse group, Michigan.

Carapace subtriangular in outline; maximum length 0.92 mm., measured midway between the dorsal and ventral margins; maximum height 0.53 mm., measured in the middle of the posterior half.

Dorsal margin gently convex, curving into the broadly rounded posterior margin; anterior margin narrowly rounded; from the exterior ventral margin appearing almost straight and rising forward, an interior view shows it to be distinctly concave at mid-length; hinge line straight, somewhat oblique, occupying about three-fourths the length of the carapace, grooved on the right valve to receive the edge of the left.

Valves somewhat flattened, the right one the larger of the two, its edge extending beyond the contact margin excepting along the mid-ventral region; grooved for the reception of the edge of the smaller left valve; the extension of the edge of the left valve beyond the contact is less marked, and appears to be confined to the ends. Surface of each valve marked by four distinct longitudinal carinae, roughly paralleling the margins of the carapace and arranged to form two curving loops, open at the anterior end, and simulating in appearance a flattened figure "C"; the dorsal carina is the sharpest and most clearly defined; weakly developed cross bars between the carinae produce a distinct pitted effect.

Anterior shell extension of each valve characterized by a number of small papillae, six being commonly present.

Remarks.—The Silica shale specimens are referred to the above variety because of the distinct pitting between the carinae which is not evident in *E. sigmoidalis* (Jones). According to Warthin, *Octonaria percarinata* Van Pelt from the Middle Devonian of Michigan is a synonym of *E. sigmoidalis* (Jones). Our specimens are very similar in general outline to *Strepula plantaris* (Jones), which Warthin likewise considers to be synonymous with the foregoing species.

Family BAIRDIIDAE Lienenklaus

Genus BAIRDIA McCoy, 1844

BAIRDIA sp.

Plate 101, figure 15

Carapace small, asymmetrical, wheat-like or spindle-shaped in lateral view; greatest length approximately midway between dorsal and ventral margins; greatest height about in center of shell; greatest thickness a little posterior of the center; length 0.67 mm.; height 0.33 mm.

Valves tumid, pinching out toward the ends, left one larger than the right and overlapping it all the way around, the overlap being most pronounced at the ends; dorsal margin almost straight in the anterior two-thirds, but becoming abruptly concave in the posterior third; hingement characters not observed; ventral margin convex, the greatest convexity occurring anterior to the center; ends narrowly rounded, the posterior almost acuminate.

Surface very finely punctate, otherwise without ornamentation.

Remarks.—This form may represent an undescribed species, but since only one specimen has been found it appears to be insufficient material to warrant specific designation. In its characteristics

it approaches most nearly *B. leguminoides* Ulrich (1891, p. 197, pl. 17, figs. 5*a–c*) but that form is larger, the overlap of the left valve is greater, and the post-dorsal concavity much less pronounced. The Silica shale form is in general less symmetrical.

Genus BYTHOCYPRIS Brady, 1880

BYTHOCYPRIS INDIANENSIS Ulrich

Plate 101, figure 16

Bythocypris indianensis ULRICH, *1891*, Cincinnati Soc. Nat. History, Jour., vol. 13, no. 4, p. 197, pl. 16, figs. 11 *a–c*, Onondaga limestone, Falls of the Ohio.—STEWART, *1930*, Ohio Jour. Sci., vol. 30, no. 1, p. 58, pl. 1, fig. 13, Silica shale, Lucas County, Ohio.

Carapace of medium size, moderately convex, kidney-shaped to semiovoid in outline; maximum length a little below the middle; maximum height in the middle of the posterior half. The dimensions of a representative specimen are: length 1.07 mm., height 0.63 mm.

Valves moderately convex; left valve larger than right, overlapping it all the way around, the overlap being greatest in the centro-ventral area; dorsal margin arched, gradually merging into the rounded cardinal extremities of which the posterior is the more angular; posterior margin broadly rounded, backward swing slight; anterior margin less broadly rounded than posterior, somewhat acuminate in some specimens; ventral margin with slight sinuosity at mid-center; surface smooth or finely punctate.

Remarks.—Identification of the Silica shale specimens with this species is made with some reservation. Many of the specimens are crushed, and some appear to be punctate which suggest an affiliation with *Bythocypris punctulata* Ulrich (1891, p. 196, pl. 17, figs. 2*a–c*). The overlap is greatest on the ventral margin and not the dorsal as I had previously thought.

BYTHOCYPRIS LUCASENSIS Stewart, n. sp.

Plate 101, figure 17

Carapace small, bean-shaped in lateral view; maximum length a little ventrad of mid-height; maximum height approximately midway between posterior and anterior; maximum thickness in the posterior fourth. The dimensions of a specimen of average size are: length 0.80 mm.; height 0.46 mm.; thickness 0.32 mm.

Valves moderately convex, the greatest convexity in the posterior half, slightly constricted centrally; left valve larger than right and overlapping it on all margins, the greatest overlap being mid-ventral; dorsal margin gently convex, merging evenly into the ends of which the anterior is the more narrowly and symmetrically rounded; hingement features not observed; ventral margin with slight concavity at mid-center; surface smooth.

Remarks.—This species resembles closely the associated *Bythocypris* sp., but may be distinguished by having the left valve overlapping the right on all margins instead of only on the dorsal and ventral, and by the less convex carapace.

Holotype.—Ohio State Univ., no. 18191.

BYTHOCYPRIS SUBQUADRATA Stewart, n. sp.

Plate 101, figures 18, 19

Carapace small, subrectangular in outline; relation of length to height about 1.6 to 1; maximum length 0.80 mm., measured a little below the mid-height of the shell; maximum height 0.48 mm., measured about one-sixth the distance from the posterior end; maximum thickness 0.36 mm., measured in the middle of the posterior half midway between dorsal and ventral margins.

Valves moderately and uniformly convex, the left the larger of the two and overlapping the right, the ventral overlap being the most prominent, and the dorsal and anterior the least prominent; dorsal margin straight to slightly arcuate; hingement features not discernible; post-cardinal angle more acute than antero-cardinal; posterior end truncate in upper part with a slight acumination

in the lower part; anterior end narrower than posterior and more symmetrically rounded; ventral margin with slight concavity at mid-length; surface smooth.

Remarks.—This species is placed provisionally in the genus *Bythocypris*. It is recognized that the shape is different from all species referred to the genus, and that the dorsal and anterior overlap are much less prominent than is common. Only two specimens have been collected, and it is felt that additional material should be at hand before a more reliable conclusion on its generic status can be reached.

Syntypes.—Ohio State Univ., no. 18192.

BYTHOCYPRIS sp.

Plate 101, figures 20, 21

Carapace small; ovoid in lateral view; maximum length midway between dorsal and ventral margins; maximum height in the middle of the posterior half; maximum thickness about the middle of the posterior half midway between dorsal and ventral margins. The dimensions are: length 0.88 mm.; height 0.53 mm.; thickness 0.40 mm.

Valves moderately and evenly convex, sloping gradually to the margins; left valve larger than right, overlapping it on the dorsal and ventral margins, the overlap being greatest centro-ventrally; dorsal margin convex; ventral margin almost straight with a slight sinuosity at mid-center; postero-cardinal slope abrupt; antero-cardinal slope long and gentle; anterior end narrowly and evenly rounded; posterior end most protuberant a little below the middle line of the shell; surface generally smooth although one specimen of the two studied appears to have a low node in the post-dorsal region.

Remarks.—These two specimens doubtless represent an undescribed species, but I feel it advisable to withhold specific designation until additional specimens can be obtained.

Genus HAMILTONELLA Stewart, n. gen.

Genotype, *Leperditia punctulifera* HALL, *1860*, New York State Mus. Nat. History, 13th Ann. Rept., p. 92, Hamilton, Eighteen-Mile Creek, New York.

Carapace medium to large in size; transversely elongate; ovate to subreniform in outline; valves equally biconvex, the left the larger of the two, and overlapping the right except along the hinge; dorsal margin convex; ventral margin convex commonly, but sometimes concave at mid-length; ends subequally rounded; one or two posterior spines on each valve, and an anterior ridge or two faintly developed anterior spines; centrally located muscle spot may be present; surface finely to coarsely reticulate.

This form has its closest counterpart in the genus *Bythocypris*, from which it may be distinguished by its different shape, and by the greater development of surface ornamentation. From *Primitiopsis*, the genus to which the genotype has been most frequently referred, it also differs in the shape, has the dorsal margin convex instead of straight, and has surface nodes and spines.

The name *Hamiltonella* is suggested for this genus in reference to the Hamilton formation of New York State, from which it was first described and of which it is so highly characteristic.

HAMILTONELLA PUNCTULIFERA (Hall)

Plate 102, figures 1–5

Leperditia punctulifera HALL, *1860*, New York State Cab., 13th Ann. Rept., p. 92, Hamilton group, New York.

Primitiopsis punctulifera JONES, 1890, Geol. Soc. London, Quart. Jour., vol. 46, p. 9, pl. 2, figs. 7, 12, 13, Hamilton group, New York.

Cytherella? bispinulatus STEWART, *1927*, Ohio Geol. Survey, 4th ser., Bull. 32, p. 60, pl. 5, figs. 18, 19, Silica shale, Silica, Ohio.

Primitiopsis unicornis VAN PELT, *1933*, Jour. Paleontology, vol. 7, p. 326, pl. 59, figs. 23–28, Bell shale, Middle Devonian, Michigan.

Cythellerina punctulifera WARTHIN, *1934*, Mus. Paleontology, Univ. Mich., Contr.,

vol. 4, no. 12, pp. 222, 223, pl. 1, figs. 24, 25, Traverse group, Michigan.

Carapace large, prominently convex, subreniform to ovoid in outline; the proportional height and length being somewhat variable, but usually about as 2 to 3. The dimensions of a specimen of average size are: length 1.65 mm. measured slightly below the middle of the valves; height 1.05 mm., measured centrally; thickness 0.73 mm., measured in the middle of the posterior third.

Valves unequal, the left larger than the right and overlapping all the way around; overlap greatest along the central third of the ventral margin where the edge folds back closely in a flange-like manner against the opposite valve, and least along the dorsal margin where there appears to be no overlap in the posterior fourth, and in some specimens scarcely any along the whole length of the margin; dorsal margin convex, curving evenly to the rounded cardinal extremities of which the posterior is the more blunt; ends subequally rounded, the anterior a little narrower than the posterior; ventral margin of right valve straight or slightly sinuate at mid-length, while ventral margin of left valve is somewhat convex.

Hinge limited to post-dorsal slope of each valve; entire periphery of left valve grooved for the reception of the edge of the smaller right valve; right valve with one or two short spines near the posterior end, and an elongate tubercle at the anterior end; left valve with one or two, less strongly developed posterior spines, and more rarely a weakly developed anterior tubercle; muscle spots smooth, centrally located, in some specimens best developed on the right valve; surface of valves reticulate due to small pits which are largest and most conspicuous in the middle portion of the valves, and minute or obsolete towards the margin.

Remarks.—This common Middle Devonian ostracode, so variable in its characteristics, is the most abundant of all the Silica shale species. Two distinct types appear to be present and it is a question in my mind whether they should both be included in the one species. One type, which I previously described as *Cytherella(?) bispinulata*, is particularly abundant in the lower zone of the shale, and is characterized by unusually coarse reticulations, two strongly developed posterior spines on each valve, a large anterior tubercle on the right valve, and a weakly developed one on the left valve. The second type, which is commonly found higher up in the shale, especially in zones 3 and 5, has the surface features less strongly developed in all cases, there being commonly only one posterior spine present on each valve (the post-ventral one) and no indication of an anterior ridge on the left valve. It is a noticeable feature of the species that the surface features are all more strongly developed on the right valve than on the left.

Casts of the interior occur quite abundantly and at first were thought to represent a different species. Fragments of the shell, however, are sometimes found adhering to the casts which definitely proves them to be this species. The form of the casts varies considerably in consonance with the shell variations. Most of the specimens have a small round depression in the post-dorsal portion of each valve which is probably a muscle attachment.

HAMILTONELLA OHIOENSIS Stewart, n. sp.

Plate 101, figures 22, 23

Carapace of medium size, moderately convex, oval to subreniform in lateral view; length 0.90 mm., measured midway between dorsal and ventral margins; height 0.53 mm., measured centrally; thickness 0.40 mm., measured in the middle of the posterior half.

Valves equally convex, unequal in size; the left larger than the right and overlapping it almost all the way around; overlap greatest on the ventral and posterior margins and least along the dorsal margin, along the posterior fourth of which the valves appear to meet evenly

with no overlap; dorsal margin convex, curving evenly to the cardinal extremities of which the posterior is slightly the more blunt of the two; hinge restricted to the post-dorsal slope of each valve; articulation features not observed; ends uniformly rounded, the posterior less broadly so than the anterior; ventral margin almost as equally convex as the dorsal margin in some specimens, but in others slightly concave at mid-length; two posterior nodes occur on each valve, of which the ventral one is the more strongly developed; two weakly developed anterior nodes spaced more closely together than those on the posterior end are present on most specimens; surface finely pitted.

Remarks.—The smaller size, absence of anterior ridge, and much less pronounced surface sculpture readily distinguish this form from *H. punctulifera* (Holl).

Syntypes.—Ohio State Univ., no. 18195.

HAMILTONELLA OHIOENSIS var. SUBCOMPRESSA Stewart, n. var.
Plate 101, figure 24

A few specimens somewhat compressed vertically and relatively longer in relation to the height are considered to be sufficiently different from the typical species to be placed under a varietal name. The dimensions are: length 0.88 mm.; height 0.42 mm.; thickness 0.38 mm.

Holotype.—Ohio State Univ., no. 18196.

Genus MACROCYPRIS Brady, 1867

MACROCYPRIS ACUTULA Stewart, n. sp.
Plate 101, figures 25, 26

Shell small, elongate; reniform to ellipsoidal in lateral aspect; maximum length 0.90 mm. measured slightly below the middle of the valves; maximum height 0.48 mm. measured in the middle of the anterior half; maximum thickness 0.40 mm. measured anteriorly.

Valves moderately and evenly convex,

EXPLANATION OF PLATE 102

All types of new species are in the Geological Museum, Ohio State University, Columbus, Ohio.

FIGS. *1–5—Hamiltonella punctulifera* (Hall). *1, 2*, Right and left valve views, ×25. *3*, Interior left view, ×25. *4*, Hinge view, ×25. *5*, Cast of interior with portion of shell adhering, ×25. Zone 3. (p. 756)

6–10—Burlella sublunata Stewart, n. sp. *6, 7*, Left valve and ventral view of female specimen, syntype, ×33, Zone 3. *8*, Hinge view of male specimen, syntype, ×33. Zone 3. *9, 10*, Exterior and interior views of right valve of male specimen, syntype, ×33. Zone 1. (p. 759)

11–13—Burlella brevispinata Stewart, n. sp. *11, 12*, Left valve and hinge views, syntype, ×37.5. *13*, Right valve view of young specimen, syntype, ×46. Zone 3. (p. 759)

14, 15—Burlella? bisulcata Stewart, n. sp. Hinge and left valve views of holotype, ×29. Zone 3. (p. 760)

16, 17—Burlella rhomboidalis Stewart, n. sp. Left valve and hinge views of holotype, ×29. Zone 3. (p. 760)

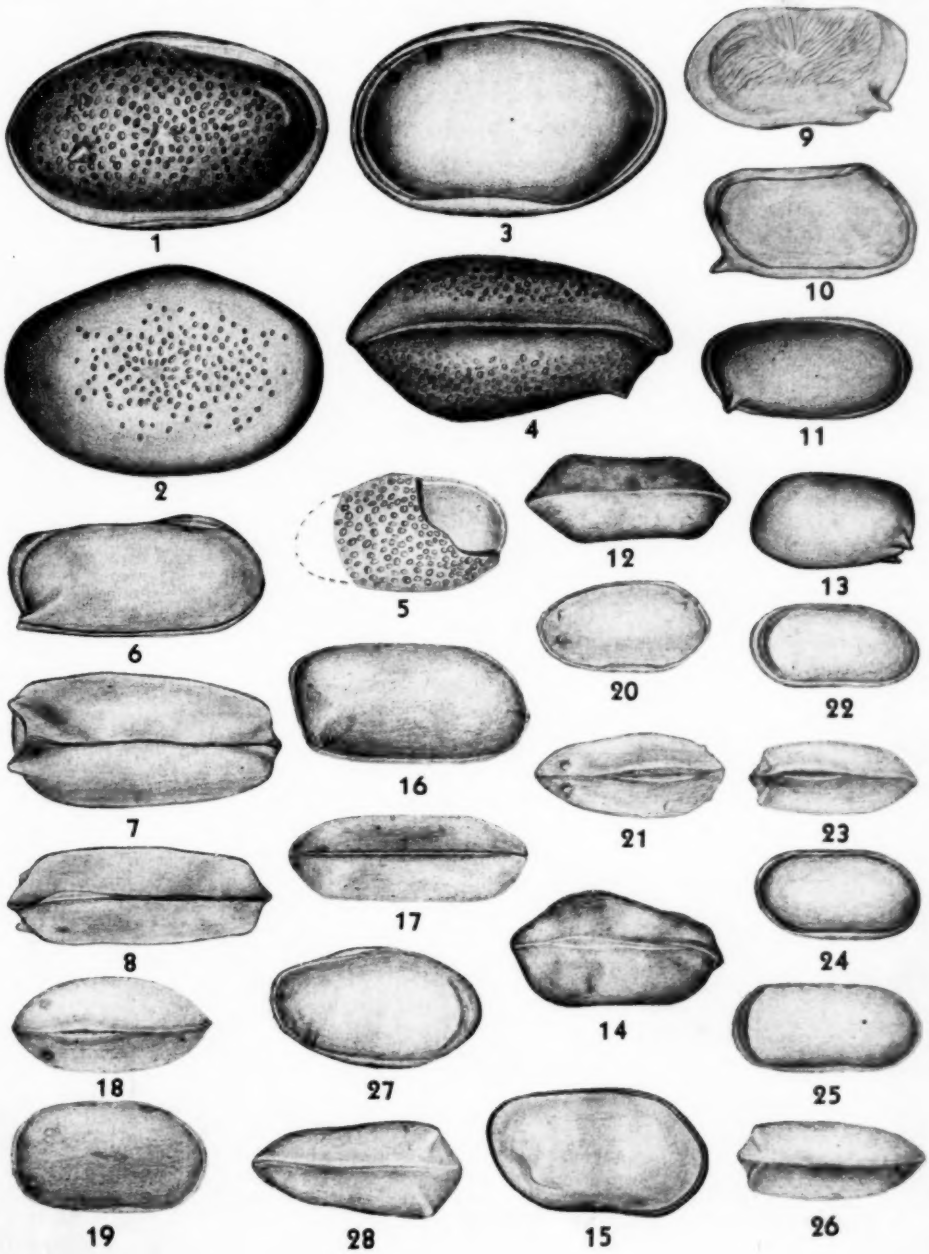
18, 19—Lucasella mundula Stewart, n. sp. Hinge and left valve views of holotype, ×33. Zone 3. (p. 761)

20, 21—Lucasella spinulifera Stewart, n. sp. Left valve and hinge views of syntypes, ×29. Zone 3. (p. 761)

22–24—Menoeidina subreniformis Stewart, n. sp. *22*, Left valve, syntype, ×29. Zone 3. *23*, Hinge view, syntype, ×29. Zone 1. *24*, Interior right valve, syntype, ×29. Zone 3. (p. 762)

25, 26—Menoeidina subreniformis var. *elongata* Stewart, n. var. Left valve and hinge views of holotype, ×29. Zone 3. (p. 763)

27, 28—Birdsallella tumida Stewart, n. sp. Right valve and hinge views of syntypes, ×33. Zone 3 (p. 763)



Stewart, Middle Devonian Ostracodes

the right larger than the left and overlapping along the ventral margin and the ends, with little or no overlap on the dorsal margin; dorsal margin convex and obliquely inclined, the anterior extremity quite blunt, the posterior long and sloping; hingement features not observed; anterior margin truncate in upper part, acuminate a little below mid-height; posterior margin long and pointed; ventral margin straight to gently convex; surface smooth.

The position of this species in the above genus is questioned. No separate valves have been observed so the internal features are not known, and it is a question in the mind of the writer whether the orientation is correct.

Syntypes.—Ohio State Univ., no. 18197.

Genus BURLELLA Coryell and Booth, 1933

BURLELLA SUBLUNATA Stewart, n. sp.

Plate 102, figures 6–10

Carapace of medium size; subovoid to subquadrate in outline; about twice as long as high; greatest length in the ventral half; greatest height in the posterior third; greatest thickness in the anterior half. The dimensions of a specimen of average size are: length 1.10 mm.; height 0.65 mm.; thickness 0.52 mm.

Valves swollen at both ends, the females being distinctly thicker than the males, somewhat depressed at mid-center. Dorsal margin smooth, straight or slightly concave at mid-length; hinge about five-sixths the length of the shell; hingement features consisting of linear grooves on the hinge below the cardinal angles in the right valve for the reception of the left valve edge, the posterior one of which is the most pronounced; hinge extremities obtusely angular; anterior end blunt, truncate in profile view, the most protuberant part in the dorsal half; posterior end more broadly rounded than the anterior, with distinct backward swing; ventral margin straight or slightly concave centrally.

Right valve larger than left, overlapping it all the way around with the exception of the antero-dorsal two-thirds; overlap greatest along the ventral and posterior margins.

Anterior end of each valve marked by a U-shaped depression, terminated ventrally by a strong spine, and dorsally by a distinct swelling. Surface of both valves with very fine anastomosing striae.

Remarks.—In its general features this species bears quite a striking resemblance to the Pennsylvanian form *B. pecanata* Coryell and Booth. It differs, however, in having a finely striated surface instead of a smooth or granulose one, in the more strongly developed antero-ventral spines, and in having the height proportionately less in relation to the length. The articulation characters of this form are evidently not very firm, as may be inferred from the fact that in many specimens one valve has been displaced along the hinge.

Syntypes.—Ohio State Univ., no. 18198.

BURLELLA BREVISPINATA Stewart, n. sp.

Plate 102, figures 11–13

Carapace elongate ovate in lateral view; about twice as long as high; greatest length midway between dorsal and ventral margins; greatest height in the middle of the posterior half; greatest thickness in the anterior half. The dimensions of an adult of average size are: length 0.77 mm.; height 0.39 mm.; thickness 0.26 mm.

Valves moderately convex, somewhat depressed in the median dorsal area, somewhat swollen near the ends; right valve larger than the left, overlapping all the way around except along the anterior two-thirds of the hinge; greatest overlap along the ventral and posterior margins; dorsal margin straight and oblique in the anterior two-thirds, slightly arched in the posterior third; cardinal extremities subequally rounded, the posterior the more obtuse of the two; hingement features not observed; posterior margin broadly rounded, most pro-

tuberant in the ventral portion, backward swing moderately pronounced; anterior margin more narrowly rounded than the posterior, gently rounded to blunt; ventral margin straight to slightly concave at mid-length.

A short, delicate, sharp spine pointing forward is located on the antero-ventral portion of each valve. Anterior U-shaped depression scarcely defined, although there is a decided flattening of the shell in this region. Surface ornamentation consisting of very fine anastomosing striae. A smooth central spot, which evidently represents a muscle attachment area, is faintly defined on some specimens.

Remarks.—This species can be distinguished from *B. sublunata* because of the different shape, the less pronounced swellings at the ends, the more delicate anterior spines, and the less noticeable U-shaped anterior depression.

Syntypes.—Ohio State Univ., no. 18199.

BURLELLA (?) BISULCATA Stewart, n. sp.

Plate 102, figures 14, 15

Carapace subquadrate in lateral view; distinctly swollen in dorsal or ventral aspect; relation of length to height about as 2 to 1; greatest length about midway between dorsal and ventral margins; greatest height in posterior half; greatest thickness in anterior third. The dimensions are 0.97 mm.; height 0.54 mm.; thickness 0.46 mm.

Valves extremely convex, swollen in the posterior and anterior regions, somewhat depressed centrally; right valve larger than left, overlapping all the way around except along the anterior two-thirds of the hinge; overlap greatest along the ventral and posterior margins; anterior two-thirds of dorsal margin channelled to form a long, narrow sulcus, posterior third gently arched; hinge features not observed. Posterior cardinal extremity long and gently curved; anterior deflected abruptly ventrally; posterior margin broadly and evenly curved; anterior margin blunt and truncate, most protuberant in the dorsal portion; ventral margin slightly concave at mid-length.

Anterior portion of each valve terminated ventrally by a stout spine, pointing forward; shell above spine somewhat flattened but not to form a distinct U-shaped depression; two faintly marked sulci, extending from the dorsal margin about two-thirds the distance to the ventral margin, are present on the posterior half of each valve, better developed on the left than the right valve. Surface marked by very fine anastomosing striations.

Remarks.—Although only one specimen (probably a fertilized female) has come under observation, it is felt to be sufficiently different from associated forms to justify separation into a distinct species. It may be distinguished from *Burlella sublunata* by the proportionately greater height, greater convexity, and the two shallow sulci on each valve. From *B. brevispinata* it may be distinguished in these same respects, and in addition by the decidedly truncate character of the anterior end.

Holotype.—Ohio State Univ., no. 18200.

BURLELLA RHOMBOIDALIS Stewart, n. sp.

Plate 102, figures 16, 17

Carapace subrhomboidal in lateral view; about twice as long as high; greatest length in ventral half; greatest height in posterior half; thickest at the ends. The dimensions are: length 1.05 mm.; height 0.51 mm.

Carapace swollen at both ends, somewhat depressed in the central area; dorsal margin almost straight, slightly arched near the posterior end; hingement features not observed; posterior cardinal angle obtuse, curving into the broadly rounded and protuberant posterior end which has a pronounced backward swing; anterior cardinal angle acute; the anterior end blunt and truncate in profile view; ventral margin essentially straight.

Right valve larger than the left, overlapping it on the free margins and on the posterior third of the dorsal margin; overlap greatest along the ventral and posterior margins. Anterior end of each valve abruptly deflected to form a rather indistinct U-shaped depression terminated both ventrally and dorsally by spines, the ventral one of which is the largest; posteriorly each valve is swollen near the margin but no spines are present. Surface of valves very finely reticulate.

Remarks.—Only one specimen of this species has been recognized. The anterior spines have been broken away but their former presence is evident where they were attached near the anterior margin. This species differs from associated species of the genus *Burlella* because of the more distinct rhomboidal shape, the antero-dorsal spine, and in having a reticulate instead of a striate surface.

Holotype.—Ohio State Univ., no. 18201.

BURLELLA sp.

A few fragmentary specimens collected from the top of zone 6 may represent an undescribed species. The specimens have the anterior spines well developed as in *Burlella sublunata*, but the anterior U-shaped depression is not so prominent, and the shape is different, being elliptical instead of subquadrate.

Genus LUCASELLA Stewart, n. gen.

Genoholotype, *Lucasella mundula* STEWART, n. sp. Silica shale (Devonian), Sandusky Cement Company quarry, one-half mile north of Silica, Lucas County, Ohio.

Carapace small; suboblong in outline; inequivalved, the right valve the larger and overlapping the left on the free margins, the ventral overlap being the greatest; dorsal margin depressed for over half of its length into a shallow sulcus; one or two anterior spines present on each valve; a posterior spine may or may not be present; surface smooth, granulose, or finely pitted.

The form seems to have its closest counterpart in the genus *Burlella* Coryell and Booth, but it lacks the characteristic U-shaped anterior depression of that genus. It also resembles *Waylandia* Coryell and Billings in many respects, but the presence of the two anterior spines in *Lucasella* serves to distinguish the two forms.

LUCASELLA MUNDULA Stewart, n. sp.

Plate 102, figures 18, 19

Carapace small, subovate in lateral view; ratio of length to height 1.8 to 1; greatest length in middle of ventral half; greatest height slightly posterior to the center; greatest thickness in the anterior half. The dimensions are: length 0.78 mm.; height 0.44 mm.; thickness 0.38 mm.

Valves equally and evenly convex, appearing somewhat swollen in marginal aspect; dorsal margin depressed in the anterior two-thirds to form a shallow sulcus, in lateral view appearing almost straight; cardinal extremities rounded, the anterior the more abrupt of the two; ends subequally rounded; anterior end blunt to almost truncate viewed laterally; posterior end broadly rounded with slight backward swing; ventral margin essentially straight with a slight concavity at mid-length.

Right valve larger than left, overlapping it on the ventral and posterior margins, the greatest overlap in the mid-ventral area; each valve with two anterior spines of which the ventral one is the more prominent; surface smooth to finely granulose.

Remarks.—Two specimens of this little form have come under observation. There seems to be no closely allied Devonian form with which to compare it.

Holotype.—Ohio State Univ., no. 18202.

LUCASELLA SPINULIFERA Stewart, n. sp.

Plate 102, figures 20, 21

Carapace small, subovoid to subpentagonal in lateral view; ratio of length to height 1.6 to 1; greatest length ap-

proximately midway between dorsal and ventral margins; greatest height in the middle of the posterior half; thickest in the anterior portion. The dimensions are: length 0.78 mm.; height 0.48 mm.; thickness 0.36 mm.

Valves moderately convex, the right valve larger than the left and overlapping on the free margins, the ventral overlap being the most prominent; dorsal margin convex in lateral view, but a dorsal view reveals a shallow sinus for about three-fourths of the length; cardinal extremities rounded, the anterior long and obtuse, the posterior short and abrupt; anterior end narrowly rounded, most protuberant in the dorsal half; posterior end broadly rounded, with a fairly well defined backward swing; ventral margin gently convex with a slight concavity at mid-length.

Two delicate spines occur on the anterior end of each valve, and one in the postero-dorsal region; surface finely pitted or granulose.

Remarks.—Two specimens have been observed which show characters distinctly different from associated forms. They may be separated readily from *Lucasella mundula* by the different shape, lesser convexity, and the posterior spine.

Syntypes.—Ohio State Univ., no. 18203.

Family CYTHERELLIDAE Sars

Genus MENOEIDINA Stewart, n. gen.

Genotype, *Menoeidina subreniformis* STEWART, n.sp. Silica shale (Devonian), Sandusky Cement Company quarry, one-half mile north of Silica, Lucas County, Ohio.

Carapace small to medium in size; elongate ovate to arc-like in outline; inequivalved, the right valve the larger and overlapping the left all the way around; dorsal margin varying from slightly convex to concave; a crescentic, forward curving ridge is present in the anterior fourth of each valve, which is steeply inclined to the anterior margin but gently inclined posteriorly; surface smooth, pitted, or finely reticulate.

This genus resembles most closely *Birdsallella* Coryell and Booth from which it may be distinguished by its different shape, the larger ventral overlap of the right valve, and in having the right valve larger than the left.

MENOEIDINA SUBRENIFORMIS Stewart, n. sp.

Plate 102, figures 22–24

Carapace small, elongate ovate to bean-like in lateral view; about twice as long as high; greatest length about midway between dorsal and ventral margins; greatest height in the middle of the posterior half; thickest in the anterior fourth. The dimensions of an adult specimen of average size are: length 0.74 mm.; height 0.42 mm.; thickness 0.30 mm.

Valves moderately convex, the right one larger than the left and overlapping it all the way around, the overlap being greatest on the ventral and post-ventral margins, and least along the dorsal margin; dorsal margin slightly arched; hinge line straight, equalling about four-fifths the length of the shell, slightly grooved in the posterior part of the right valve for the reception of the edge of the smaller left valve; postero-cardinal extremity long and sloping; antero-cardinal extremity acute; posterior end somewhat attenuate, with slight backward swing; anterior end narrowly rounded, and blunt to truncate in appearance; ventral margin slightly sinuate at mid-length. A short distance from the anterior end the surface of each valve becomes elevated into a crescentic, anteriorly curving ridge, which has a long, gentle posterior slope, and a short, steep anterior slope; the ridge is highest in the center, and gradually diminishes in height towards the posteriorly directed ends.

Surface of valves finely reticulate or punctate.

Remarks.—This species is especially characterized by its bean-like shape, anterior crescentic ridge on each valve, and sloping postero-cardinal extremity. It commonly occurs as casts of the interior, although separate valves are also

present in comparative abundance. The form is especially abundant at the base of the Silica shale.

Syntypes.—Ohio State Univ., no. 18204.

MENOEIDINA SUBRENIFORMIS var. ELONGATA Stewart, n. var.

Plate 102, figures 25, 26

A few specimens which are relatively longer than the typical *Menoeidina subreniformis* are here given a varietal name. In addition the ventral and dorsal margins are straighter, and more nearly parallel to one another than in the species. The dimensions are: length 0.84 mm.; height 0.37 mm.

Holotype.—Ohio State Univ., no. 18205.

Genus BIRDSALLELLA Coryell and Booth, 1933

BIRDSALLELLA TUMIDA Stewart, n. sp.

Plate 102, figures 27, 28

Carapace of medium size, tumid; elliptical in lateral view; wedge-shaped in dorsal or ventral aspect; maximum length midway between dorsal and ventral margins; maximum height approximately midway between the ends; thickest in the anterior fifth of the shell. The dimensions of a specimen of average size are: length 0.88 mm.; height 0.46 mm.; thickness 0.42. mm.

Valves extremely convex, somewhat compressed vertically, the left one larger than the right and overlapping it slightly all the way around; dorsal margin gently convex to almost straight; hinge features not observed; ventral margin with a slight sinuosity at mid-length, rising slightly backward; both ends narrowly rounded, attenuate in some specimens, the anterior usually the more symmetrically curved of the two.

A short distance from the anterior end the valves become extremely swollen, and in the more tumid specimens are surmounted by a distinct anteriorly curving ridge; the ridge has a long, gentle posterior slope, and a short, abrupt anterior slope; valves somewhat flattened in the central portion; surface of valves smooth.

Remarks.—Specimens of this species were submitted to Dr. H. N. Coryell for inspection, who expressed the opinion that they probably belonged to the genus *Birdsallella* but represented a different species from the genotype *B. simplex* Coryell and Booth from the Wayland shale of Pennsylvanian age in Texas. *B. tumida* differs from *B. simplex* in having a greater overlap, thicker anterior end with respect to the posterior, and in the lower posterior end in relation to the greatest height which is more nearly central.

Valves in articulation have not been seen so that much difficulty has been experienced in orientating the specimens. I have, therefore, followed the lead of Coryell and Booth in considering the left valve to be the larger and overlapping one, and the ridges to be anteriorly placed.

Syntypes.—Ohio State Univ., no. 18206.

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GRACE A. STEWART, OHIO STATE UNIVERSITY, COLUMBUS, OHIO. MANUSCRIPT RECEIVED BY THE EDITOR, JULY 15, 1936.

JOURNAL OF PALEONTOLOGY, VOL. 10, NO. 8, PP. 764–768, TEXT-FIGS. 1*a–h*, DECEMBER, 1936

STRUCTURAL TRENDS OF THE TROCHILISCACEAE

RAYMOND E. PECK

ABSTRACT

Three new species of Trochiliscaceae from a Devonian shale below the Mineola (Onondaga) limestone of northeastern Missouri are older and more primitive than any yet recorded and are of value in indicating the structural trends of the family. From the pre-Onondaga to Lower Mississippian the trend was toward larger size, reduced number of spiral units, calcification of the coronula cells, and more complete calcification of the enveloping cells.

The Trochiliscaceae are an extinct group of the Charophyta that is represented by oogonia only. These oogonia differ from those of the modern charophytes in possessing more than five spiral enveloping units and in the spirals twisting to the right instead of to the left.

Trochiliscaceae are abundantly represented in the Devonian of some European localities and these occurrences have been adequately described by Karpinsky (1906). They are also very abundant in several Devonian and Kinderhook formations in North America from which I have recently described several species and discussed the systematic relationships of the family (Peck, 1934). Since the completion of this work, E. B. Branson and M. G. Mehl have provided me with additional material from a Devonian shale that outcrops in a small area in Ralls County, 10 miles southwest of Hannibal, Mo. The shale rests on Kimmswick (Trenton) limestone and is overlain by a sparsely fossiliferous Devonian limestone identified as Mineola (Onondaga) (see Branson, 1923). The Trochiliscaceae are abundant at every outcrop and through the entire thickness of the shale, in places making up half or more of the residue of washed samples. The only other fossils found in association are poorly preserved ostracodes of uncertain affinities. This new trochiliscid material contains forms that are more primitive than any previously recorded from North America. These species make it possible to point out structural trends in the Trochiliscaceae with a greater degree of confidence than hitherto possible, and the extended range should increase the stratigraphic value of the group.

Approximately four-fifths of the Trochiliscaeceae from the shale in Ralls County possess 10 spiral ridges, A small proportion has 9 spirals and a somewhat larger number has 11 spirals. This is the first record of an 11-spiralled form and the first occurrence in which 10 spirals is the dominant number.

Karpinsky (1906) found that most of his specimens from the Devonian of central Europe possessed 8 or 9 enveloping units, but that one species, *Trochiliscus ingricus* Karpinsky, had 18 spirals. However, as I have previously shown (Peck, 1934, p. 91, pl.

9, fig. 12*b*), it is possible for the enveloping cells to calcify only in part in such a way that each cell is represented on the surface of the oogonium by 2 ridges. Trochiliscaceae with 18 spiral ridges probably represent 9-celled oogonia. Although excellent preservation and careful cross-sectioning of the spirals would be necessary to prove that *T. ingricus* Karpinsky possessed 9 rather than 18 enveloping cells, Karpinsky's, (1906, pl. 2, figs. 23–28) illustrations indicate the possibility of the double-ridged preservation of each cell. A cross-section calculated to cut part of the enveloping spirals at right angles will, because of the spiral nature of the cells, show sections of nearly all of the cells in half the circumference of the section (see sections of *T. laticostatus* Peck, 1934, pl. 11). Not all of the cells will be cut at right angles and the width of the spirals varies in such a section. Karpinsky's cross-section of *T. ingricus* Karpinsky shows 9 cells in half the circumference of his section. Also, in his figures of summit views alternating pairs of ridges meet to form an inverted V near the summit opening. The furrows formed between the ridges that meet are cellular furrows and between those that do not meet are intercellular furrows (compare with Peck, 1934, pl. 9, figs. 12*b*, 13*a*; pl. 11, figs. 1, 12, 18).

If *T. ingricus* Karpinsky is a 9-celled form, the greatest number of spiral cells described on any trochiliscid is 10. *T. lemoni* (Knowlton) from the Onondaga limestone at the Falls of the Ohio, *T. bellatulus* Peck from the Columbus limestone on Kelly's Island, *T. meeki* Peck from the Hackberry shale of Iowa, and *T. decemcostatus* Peck from the Kinderhook of Missouri have 10 spiral units. Each of these forms is associated with more abundantly represented species that have a smaller number of spirals.

I have come to the conclusion that the number of spirals is of importance in defining species and perhaps groups of even higher rank. Although as a rule, there are other characters that are distinctive of species differentiated on the basis of numbers of spirals, in some assemblages this is the only distinguishing character that can be used. Karpinsky did not consider the number of spirals of value and assigned oogonia with variable numbers to the same species. Regardless of the taxonomic value, a study of the stratigraphic distribution of numbers of spiral enveloping units shows clearly the progressive loss of them and suggests that the proportions of different numbers give evidence as to the relative age of the matrix.

The 11-spiralled species described below is the oldest form so far recorded, with the possible exception of *T. ingricus* Karpinsky, but an abundant 10-spiralled species and a rare 9-spiralled species occur with it. The next younger record comes from the Onondaga limestone in which *T. devonicus* (Wieland), a much larger 9-spiralled species, is the most abundant, but it is associated with *T. lemoni* (Knowlton) and *T. bellatulus* Peck, 10-spiralled species. In the

Onondaga also occur 8-spiralled and 9-spiralled coronulate species, the oldest representatives of the genus *Trochiliscus* to have coronula cells preserved. *T. herbertae* Peck, a small species from the Bell shale (upper Middle Devonian) is the oldest trochiliscid with cellular ridges, showing complete calcification of the enveloping cells. Only a few of the 50 specimens examined, however, showed cellular ridges. In the Hackberry (Upper Devonian), a 9-spiralled coronulate species, *T. bilineatus* Peck, is the most abundant form. This is associated with a 10-spiralled coronulate species, *T. meeki* Peck, an 8-spiralled coronulate species, *T. liratus* Peck, a 7-spiralled coronulate species, *T. raricostatus* Peck, and an 8-spiralled noncoronulate species, *T. raricostatus* Peck, and an 8-spiralled noncoronulate species, *T. rugulatus* Peck. *T. rugulatus* ranks second to *T. bilineatus* in abundance. In the basal Kinderhook beds of Missouri, *T. laticostatus* Peck, a large 9-spiralled coronulate species, is the most abundant representative of the genus. Kinderhook trochiliscids are larger than the Devonian forms, all are coronulate, and many had reached the stage of complete calcification of the enveloping cells. Ten-spiralled forms are rare, 8-spiralled forms abundant, and 7-spiralled forms more abundant than in the Hackberry Devonian.

To summarize, the Trochiliscaceae first appeared in the Devonian. They were small oogonia with a comparatively large number of enveloping cells. The trend was toward larger size, reduced number of enveloping cells, calcification of the coronula cells, and more complete calcification of the enveloping cells. These data are presented graphically in the accompanying chart.

The trochiliscids have not been found widely enough distributed to justify close correlation based on them alone, but the comparatively rapid and distinctive changes outlined above suggest that they may afford excellent contributory evidence for the correlation of Devonian and Mississippian strata.

Structural trends of the Trochiliscaceae. Only large assemblages considered.

		SIZE	SEVEN SPIRALS	EIGHT SPIRALS	NINE SPIRALS	TEN SPIRALS	ELEVEN SPIRALS	CORONULATE	CELLULAR RIDGES
MISSISSIPPIAN	KINDERHOOKIAN	large 0.8 to 1 mm.	rare	many	majority	rare	none	all	many
DEVONIAN	HACKBERRY	medium 0.6 to 0.8 mm.	very rare	many	majority	rare	none	majority	rare
	ONONDAGA	0.6 to 1 mm.	none	rare	majority	several	not noted	rare	none
	RALLS COUNTY DEVONIAN SHALE	small 0.3 to 0.4 mm.	none	none	rare	large majority	rare	none	none

SYSTEMATIC DESCRIPTIONS

Genus TROCHILISCUS Karpinsky

TROCHILISCUS MINUTUS Peck, n. sp.

Text-figures 1*e–h*

Oogonium noncoronulate, subspherical, small, ranging from 0.3 mm. to 0.4 mm. in diameter, the summit and base slightly produced, the summit more than the base, to give a greater length than width. Ridges intercellular, nine, fairly sharp, making a half turn around the oogonium and recurving to an almost vertical position near the summit. Spiral furrows cellular in position, comparatively broad and deep.

Occurrence.—Shale at the base of the Mineola (Onondaga) limestone, 2½ miles southwest of Rensselaer, Ralls County, Mo.

Syntypes.—Univ. Missouri, no. 31011–1.

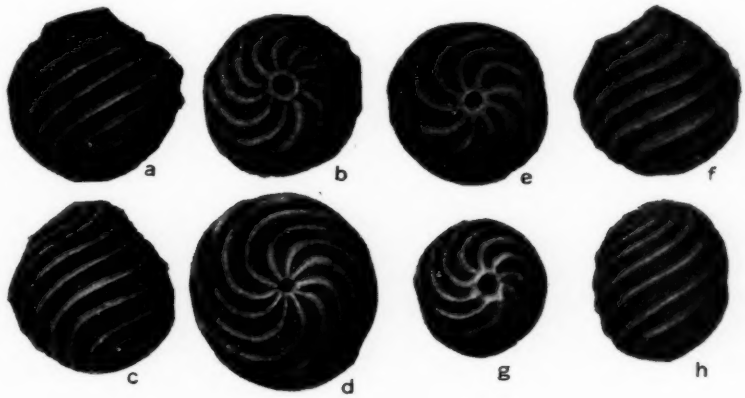
Remarks.—Representatives of this species are not abundant, occurring with *T. convolutus*, n. sp., in the proportion of about 1:100. The only constant difference between the two species is in the number of spiral ridges. *T. bulbiformis* Karpinsky, while approaching *T. minutus* closely in size, shape, and number of spirals, is wider than long, and more bulb-shaped.

TROCHILISCUS CONVOLUTUS Peck, n. sp.

Text-figures 1*c*, *d*

Oogonium noncoronulate, small, averaging from 0.3 mm. to 0.4 mm. in diameter; almost spherical, the summit always slightly produced and the base usually slightly produced to give a somewhat greater length than width. Ridges intercellular, ten, fairly sharp, making a half turn around the oogonium and recurving to an almost vertical position near the summit. Spiral furrows cellular in position, comparatively broad and deep.

Occurrence.—Shale at the base of the Mineola (Onondaga) limestone, 2½ miles southwest of Rensselaer, Ralls County, Mo.



EXPLANATION OF TEXT-FIGURE 1

All specimens ×56

a, *b*—*Trochiliscus multivolvis* Peck, n. sp. Lateral and basal views of the holotype.

c, *d*—*Trochiliscus convolutus* Peck, n. sp. Lateral and basal views of the syntypes.

e–h—*Trochiliscus minutus* Peck, n. sp. *e*, *f*, Basal and lateral views of normal sized syntype. *g*, *h*, Basal and lateral views of small syntype.

Syntypes.—Univ. Missouri, no. 31011–2.

Remarks.—This species is exceptionally abundant throughout the small outcrop area of this Devonian shale. The residue of some washed and screened samples consists more than half of Trochiliscaceae, four-fifths of which are representatives of *T. convolutus*. It is easily distinguished from *T. lemoni* (Knowlton) from the Onondaga at the Falls of the Ohio by its small size and sharp intercellular ridges. *T. bellatulus* Peck from the Columbus limestone on Kelly's Island, Ohio, is fairly large, averaging 1 mm. in diameter. *T. bulbiformis* Karpinsky from the Devonian of the U.S.S.R. greatly resembles *T. convolutus* in size and shape, but *T. bulbiformis* is wider than high and is described as having 8 or 9 spirals.

TROCHILISCUS MULTIVOLVIS Peck, n. sp.

Text-figures 1*a*, *b*

Oogonium noncoronulate, small, ranging from 0.3 mm. to 0.4 mm. in diameter almost spherical, the summit and base slightly produced, the summit more than the base, to give a somewhat greater length than width. Ridges intercellular, eleven, fairly sharp, making a half turn around the oogonium and recurving to an almost vertical position near the summit. Spiral furrows cellular in position, comparatively broad and deep.

Occurrence.—Shale at base of Mineola (Onondaga) limestone 2½ miles southwest of Rensselaer, Ralls County, Mo.

Holotype.—Univ. Missouri, no. 31011–3.

Remarks.—The only constant difference between *T. multivolvis* and the two species described above is the number of spiral ridges.

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CARBONIFEROUS OSTRACODES

BETTY KELLETT

ABSTRACT

The new family Graphiodactylidae is instituted for the genus *Graphiodactylus* Roth which was formerly in the Kirkbyidae, and the hinge structure and early molts of this group are discussed. The generic name *Antiparaparchites* Coryell and Rogatz is placed in the synonymy of *Paraparchites* Ulrich and Bassler, reversal of valves being not uncommon among ostracodes; and the genus *Kegelites* Coryell and Booth is shown to be founded on a young specimen of *Amphissites dattonensis* Harlton. The genus *Mammoides* Bradfield is referred to *Aechminella* Harlton. *Coryellites* Kellett is a new name for the genus *Coryellina* Kellett (not Bradfield); and *Healdia coryelli* Kellett is a new name for *H. compressa* Kellett (not Coryell and Billings). Thirty-two names of ostracode species are placed in synonymy, many of the forms on which they were based being young or sexual variants of previously described species. *Ellipsella calcar* (Harlton), *Aechminella mammoides* (Bradfield), and *Geisina arcuata* (Bean) are new combinations. Six species are added to Knight's faunal list of the St. Louis Pennsylvanian outlier, which is revised and brought up to date.

During the last eight years I have fortunately had the opportunity of examining many Carboniferous ostracodes from both subsurface and surface formations including many primary types and topotypes. Many of these shells come from localities where hundreds of well-preserved specimens can be found in a single sample. A study of this material, as well as papers by Ulrich and Bassler, Van Veen, Swartz, Geis, Alexander, Johnson, Wilson, and Harper and Sutton, has convinced me that within each species of ostracodes many variations may be found. These variations, which may be either individual or due to sex and age, have been discussed in my papers on the Kansas ostracodes. Failure to recognize such variations within certain species has led to some of the overnaming which exists in the literature on Carboniferous ostracodes. Other causes which have contributed to this multiplication of names are the rapidity with which the literature of this group has appeared, the inadequacy of some of the figures, and the use as types of badly weathered, broken or distorted specimens.

In the following pages thirty-two specific names are placed in synonymies and various additions and corrections are made to the work of myself and others. Moreover, I believe that with further study additional specific names, especially in the genus *Healdia*, will be relegated to synonymy.

This paper is divided into two parts; the first is composed of notes on various Carboniferous ostracodes, while the last is concerned with the fauna of the St. Louis Lower Pennsylvanian outlier.

I wish to repeat my thanks to Dr. R. S. Bassler, Dr. R. C. Moore, Dr. H. N. Coryell, Dr. G. E. Condra, Mr. B. H. Harlton, and to the executives of the Amerada Petroleum Corporation for facilitating the examination of material upon which this work is based. I wish also to thank Mr. N. L. Thomas and Mr. Ralph Brant for gifts of material. The

discussion of certain problems with Mr. W. R. Johnson who is studying the ostracodes of Nebraska has been very helpful, and the assistance of Dr. J. B. Knight has made possible the work on the fauna of the St. Louis outlier. Mr. M. C. Israelsky kindly gave me reference to Terquem's work on reversal of valves.

See this jour., v. 11, no. 1, p. 80, 1937 for correction of this page.

SYSTEMATIC DESCRIPTIONS

Family LEPERDITELLIDAE Ulrich and Bassler, 1906

Genus PARAPARCHITES Ulrich and Bassler, 1906

Paraparchites ULRICH and BASSLER, *1906*, U. S. Nat. Mus., Proc., vol. 30, pp. 149, 150.—GRABAU and SHIMER, *1910*, North Am. Index Fossils, p. 343.—HARLTON, *1929*, Am. Jour. Sci., ser. 5, vol. 18, p. 254.—KELLETT, *1933*, Jour. Paleontology, vol. 7, p. 63.—LATHAM, *1932*, Roy. Soc. Edinburgh, Proc., vol. 57, pt. 2, p. 353.—UPSON, *1933*, Nebraska Geol. Survey, Bull. 8, p. 11. BASSLER and KELLETT, *1934*, Bibl. Index Paleozoic Ostracoda, p. 16.

Antiparaparchites CORYELL and ROGATZ, *1932*, Am. Midland Naturalist vol. 13, p. 387, pl. 34, figs. 3, 4 (see explanation pl. 35).

The genus *Antiparaparchites* Coryell and Rogatz was based on the single species *A. reversus* and was originally described:

Antiparaparchites differs from *Paraparchites* in the reversal of orientation of carapace; left valve overlaps right along free border of *Antiparaparchites;* reversed in *Paraparchites.*

PARAPARCHITES OVIFORMIS Coryell and Rogatz

Paraparchites oviformis CORYELL and ROGATZ, *1932*, Am. Midland Naturalist, vol. 13, p. 387, pl. 34, figs. 1, 2 (see explanation pl. 35). Arroyo formation, Clear Fork group, Permian; Tom Green County, Texas. (Type examined.)

Antiparaparchites reversus CORYELL and ROGATZ, *1932*, Am. Midland Naturalist, vol. 13, p. 388, pl. 34, figs. 3, 4 (see explanation pl. 35). Arroyo formation; Tom Green County, Texas. (Type examined.)

Paraparchites thomasi CORYELL and SAMPLE, *1932*, Am. Midland Naturalist, vol. 13, p. 248, pl. 24, fig. 1. (Type examined.)

Paraparchites palopintoensis CORYELL and SAMPLE, *1932*, Am. Midland Naturalist, vol. 13, p. 248, pl. 24, fig. 4. (Type examined.)

Paraparchites brazoensis CORYELL and SAMPLE, *1932*, Am. Midland Naturalist, vol. 13, p. 249, pl. 24, fig. 5. (Type examined.)

Paraparchites oblongus CORYELL and SAMPLE, *1932*, Am. Midland Naturalist, vol. 13, p. 250, pl. 24, fig. 3. (Type examined.)

An examination of the holotypes of *A. reversus* Coryell and Rogatz and *Paraparchites oviformis* Coryell and Rogatz, which occurred together, and also of topotype material in which both of these species are abundant, shows the two forms to be identical except for the reversal of the overlap and hinge structure. Because it is now known that such reversal of overlap within a species is not uncommon among ostracodes it is reasonable to suppose, as suggested by Johnson (1936, p. 7), that these two forms are not only congeneric, but also conspecific, and that *Antiparaparchites* is a synonym of *Paraparchites.* Similar reversals of valve size and hinge structure within a species have been noted in post-Paleozoic genera by Terquem (1886, p. 99) and by C. I. and C. W. Alexander (1933, pp. 280–283, text-figs. 1–4), and in Carboniferous *Sansabella* by Morey (1935, p. 476) and by Johnson (1936, p. 7).

The specimens on which the above species were based range in length from 0.37 mm. to 0.56 mm. and are all from the East Mountain shale at Mineral Wells, Texas. I am convinced that they all belong to the same species, the smaller specimens being the earlier molts. The small specimen called *P. thomasi* has the oblique anterior and prominent spine which are quite characteristic of other young *Paraparchites*, for example, *P. humerosus* (see Kellett, 1933, pl. 13, figs. 1–12). The other specimens with progressive size are straighter ventrally and less oblique at the ends, while the growth of the spine does not keep pace with the rest of the valve. Such changes in successive molts are typical of species of the genus *Paraparchites*, and are seen

also in the development of *P. latidorsatus* Warthin, see page 779.

Genus PSEUDOPARAPARCHITES Kellett, 1933

Pseudoparaparchites KELLETT, *1933*, Jour. Paleontology, vol. 7, no. 1, p. 67.

The "thickened band on the interior of the valves along the free edges" mentioned in the original description of this genus is now known to be a well-developed "calcareous inner lamella" (see Alexander, 1933, pp. 179–184, pl. 25). The prominent development of the inner calcareous lamella should serve to aid in differentiating this genus from *Paraparchites*, which apparently lacks this feature.

Family DREPANELLIDAE Swartz, 1936

Genus CORNIGELLA Warthin, 1930

CORNIGELLA MINUTA Warthin

Cornigella minuta WARTHIN, *1930*, Okla. Geol. Survey, Bull. 53, p. 59, pl. 4, figs. 7*a–c*. Wetumka and Holdenville formations, Pennsylvanian, Oklahoma. (Type examined.)—CORYELL and SAMPLE, *1932*, Am. Midland Naturalist, vol. 13, p. 253, pl. 24, fig. 6. East Mountain shale, Mineral Wells formation, upper Strawn group; Mineral Wells, Texas. (Type examined.)—JOHNSON, *1936*, Nebr. Geol. Survey, Paper 11, p. 19, pl. 1, figs. 15, 16. Kansas City group, Missouri series; Nebraska.

Cornigella longispina CORYELL and SAMPLE, *1932*, Am. Midland Naturalist, vol. 13, p. 254, pl. 24, fig. 12, East Mountain shale; Mineral Wells, Texas. (Type examined.)

C. minuta and *C. longispina*, which are found together at Mineral Wells, Tex., and at many other places, are supposedly differentiated by the greater development of the two small nodes at the cardinal angles on *C. minuta*, and by the greater development of the large anterodorsal node on *C. longispina*. The nodes at the cardinal angles are at best small and inconspicuous, however, and their degree of development cannot be considered to be of specific importance. Furthermore, all degrees of development of this anterior dorsal node or spine, including the maximum supposedly characteristic only of *C. longispina*, may be seen on typical 8-noded *C. minuta* (see Warthin's figures). Johnson, too, believes that these forms are "not clearly distinct," and mentions that a well-developed dorsal spine is present on some of the Nebraska specimens which he refers to *C. minuta*.

The genera *Aechminella* and *Cornigella* are provisionally placed in this family because of a resemblance to *Bollia americana* var. *zygocornis* Swartz (1936, pl. 88, figs. 3*a–d*).

Genus AECHMINELLA Harlton, 1933

Aechminella HARLTON, *1933*, Jour. Paleontology, vol. 7, p. 19, pl. 7, figs. 1*a*, *b*. Johns Valley shale, lowermost Pennsylvanian; southern Oklahoma.

Mammoides BRADFIELD, *1935*, Bull. Am. Paleontology, vol. 22, no. 73, p. 37, pl. 1, fig. 21. Deese (?) formation, Lower Pennsylvanian; southern Oklahoma.

The differences between *Mammoides mammillata* Bradfield, the genotype of *Mammoides*, and the similar *Aechminella buchanani* Harlton, appear to be so slight as to be of only specific importance, and therefore *Mammoides* is referred to the synonomy of *Aechminella*. *Aechminella mammillata* (Bradfield) is a new combination.

Family KLOEDENELLIDAE Ulrich and Bassler, 1923

Genus ELLIPSELLA Coryell and Rogatz, 1932

ELLIPSELLA OBLIQUA Coryell and Rogatz

Ellipsella obliqua CORYELL and ROGATZ, *1932*, Am. Midland Naturalist, vol. 13, p. 39, pl. 34, figs. 7, 8 (see explanation pl. 35). Arroyo formation, Permian; Texas. (Type examined.)

Ellipsella gilei CORYELL and ROGATZ, *1932*, Am. Midland Naturalist, vol. 13, p. 39, pl. 34, figs. 9, 10 (see explanation pl. 35). Arroyo formation, Texas. (Type examined.)

According to the work done by Geis (1932, pp. 150–160) and Swartz (1933, pp. 231–239) on this same family, the orientation of the above forms should be reversed. *E. obliqua* is quite thick posteriorly and *E. gilei* much thinner pos-

teriorly, *E. obliqua* being the female and *E. gilei* the male of the species. *E. distenta* (Kellett, 1933, pp. 82, 83, pl. 13, figs. 14–16, 18–20) shows the same male and female variants.

ELLIPSELLA CALCAR (Harlton), n. comb.

Cytherella calcar HARLTON, *1928*, Jour. Paleontology, vol. 2, p. 41, pl. 21, figs. 16*a*, *b*. Graham formation, Texas. (Type examined); *1929*, Texas Univ., Bull. 2901, p. 161, pl. 4, fig. 9. Graham formation, Texas.

Cytherella calcar Harlton (?). CORYELL and OSORIO, *1932*, Am. Midland Naturalist, vol. 13, p. 39. Nowata shale, Oklahoma.

Jonesina ampla WARTHIN, *1930*, Okla. Geol. Survey, Bull. 53, p. 61, pl. 4, figs. 8*a*, *b*. Wetumka and Holdenville formations, Oklahoma.

Jonesina acuneata WARTHIN, *1930*, Okla. Geol. Survey, Bull. 53, p. 61, pl. 4, figs. 9*a*, *b*. Wetumka formation, Oklahoma.

Ellipsella (?) *distenta* KELLETT, *1933*, Jour. Paleontology, vol. 7, p. 82, pl. 13, figs. 14–16, 18–20. (?) Lansing group, Pennsylvanian, to Winfield formation, Permian; Kansas.

Ellipsella distenta KELLETT, *1935*, Jour. Paleontology, vol. 9, p. 162.

Jonesina hoxbarana BRADFIELD, *1935*, Bull. Am. Paleontology, vol. 22, no. 73, p. 40, pl. 2, figs. 10*a*, *b*. Hoxbar formation, Middle Pennsylvanian, Oklahoma.

Ellipsella ampla JOHNSON, *1936*, Nebr. Geol. Survey, Paper 11, p. 23, pl. 2, figs. 8–10. Kansas City group, Nebraska.

Genus KNOXINA Coryell and Rogatz, 1932

KNOXINA LECTA Coryell and Rogatz

Knoxina lecta CORYELL and ROGATZ, *1932*, Am. Midland Naturalist, vol. 13, p. 383, pl. 35, figs. 1–3 [see explanation pl. 34]. Arroyo formation, Permian; Texas. (Type examined.)

Knoxina elliptica CORYELL and ROGATZ, *1932*, Am. Midland Naturalist, vol. 13, p. 384, pl. 35, figs. 4–6. Arroyo formation, Texas. (Type examined.)

Knoxina incurvata CORYELL and ROGATZ, *1932*, Am. Midland Naturalist, vol. 13, p. 385, pl. 35, figs. 7–9. Arroyo formation, Texas. (Type examined.)

Knoxina indistincta CORYELL and ROGATZ, Am. Midland Naturalist, vol. 13, p. 386, pl. 35, figs. 10–12. Arroyo formation, Texas. (Type examined.)

Knoxina elliptica and *K. lecta* are the male and female forms of this species, the form figured as *K. lecta* with the thickened posterior (anterior in the original description) being the female. *K. incurvata* and *K. indistincta* are small immature specimens differing from the adults in their well developed costae, more oblique post-ventral margins (orientation reversed in accordance with Geis), and less prominent overlaps. This slight overlap is characteristic of most young Carboniferous ostracodes, not only of the Kloedenellidae but of other families. The oblique post-ventral slope is also quite characteristic of the young of the Kloedenellidae, as can be seen in ontogenetic series (Kellett, 1933, pl. 14, figs. 1–8, 20–27).

Family KIRKBYIDAE Ulrich and Bassler, 1923

Genus AMPHISSITES Girty, 1910; Emend. Knight, 1928

Amphissites GIRTY, *1910*, New York Acad. Sci., Ann., vol. 20, p. 235.—BASSLER and KELLETT, *1934*, Bibl. Index Paleozoic Ostracoda, pp. 32, 149 (gives more synonymy.)

Albanella HARRIS and LALICKER, *1932*, Am. Midland Naturalist, vol. 13, p. 397.—KELLETT, *1935*, Jour. Paleontology, vol. 9, p. 163.

Girtyites CORYELL and BOOTH, *1933*, Am. Midland Naturalist, vol. 14, p. 261, pl. 3, figs. 4–6.

Kegelites CORYELL and BOOTH, *1933*, Am. Midland Naturalist, second page of the table of contents to vol. 14. (A new name for *Girtyites*, preoccupied.)

Kegelites spinosus (Coryell and Booth) is the genotype of *Kegelites* and its only species. Therefore, since Johnson (1936, p. 30) and I have independently come to the conclusion that *K. spinosus* is merely a very early molt of *A. dattonensis* Harlton, with which it occurs not only at the type locality but at numerous other horizons, it follows that we regard *Kegelites* as a synonym of *Amphissites*.

AMPHISSITES DATTONENSIS Harlton

Amphissites dattonensis HARLTON, *1927*, Jour. Paleontology, vol. 1, p. 207, pl. 32, figs. 9*a*, *b*. Upper Glenn formation, Pennsylvanian; Oklahoma.—BASSLER and KELLETT, *1934*, Bibl. Index Paleozoic Ostracoda, p. 150 (more synonymy given here.)—JOHNSON,

1936, Nebr. Geol. Survey, Paper 11, p. 29, pl. 3, figs. 16–19. Lansing and Kansas City groups, Nebraska.

Amphissites irregularis CORYELL and SAMPLE, *1932*, Am. Midland Naturalist, vol. 13, p. 261, pl. 25, fig. 5. East Mountain shale, upper Strawn; Texas.

Girtyites spinosus CORYELL and BOOTH, *1933*, Am. Midland Naturalist, vol. 14, p. 261, pl. 3, figs. 4–6. Wayland shale, Graham formation; Texas.

Kegelites spinosus (CORYELL and BOOTH), *1933*, Am. Midland Naturalist, second page of the table of contents to vol. 14.

The minute form called *Girtyites spinosus* differs from *Amphissites dattonensis* in the narrower anterior in lateral view, in the greater development of the antero-dorsal node, and in the lack of the anterior and ventral carinae. However, these differences are all characteristic of young *Amphissites* (Kellett, 1933, pl. 14, figs. 40–42; pl. 15, figs. 12–22; pl. 16, figs. 16–22). Early molts of *A. rugosus* Girty, the genotype of *Amphissites*, show the antero-dorsal node extending above the hinge line, while the innermost carina, present on the adult specimens, is lacking on the earliest molts. After finding intergrading specimens between the small *K. spinosus* and the typical adult *A. dattonensis* there seems to be no doubt that *K. spinosus* is an early molt of *A. dattonensis*. *A. irregularis* is a molt midway between the above two forms. It is matured enough to have partially developed carinae and to have lost the spinous character of the antero-dorsal shoulder, and yet young enough that this shoulder still extends above the hinge line.

Family GRAPHIODACTYLIDAE Kellett, new family

Genus GRAPHIODACTYLUS Roth, 1929

Graphiadactyllis ROTH, *1929*, Wagner Free Inst. Sci., Pub., vol. 1, p. 10.

Graphiodactylus ROTH, *1929*, Jour. Paleontology, vol. 3, pp. 292, 293.—BASSLER and KELLETT, *1934*, Bibl. Index Paleozoic Ostracoda, p. 34.

Bassleria HARLTON, *1929*, Am. Jour. Sci., ser. 5, vol. 18, p. 255.

Paracythere ULRICH and BASSLER, *1932*, Tennessee Div. Geology, Bull. 38, pl. 27, figs., 4, 13.—MOREY, *1936*, Jour. Paleontology, vol. 10, p. 117. (*Paracythere* placed in the genus *Graphiadactylus*.)

Graphiodactylus is the type genus and as yet the only genus included in the new family Graphiodactylidae. It occurs from the Devonian to the Early Pennsylvanian, a number of species occurring in the Mississippian. *Graphiodactylus* is removed from the Kirkbyidae for the following reasons: (1) *Graphiodactylus* is more oblique in lateral view than typical Kirkbyidae. (2) It lacks the depressed muscle spot and the prominent nodes and carinae common to the Kirkbyidae. (3) The character and position of the marginal flanges are quite different in the two groups. In the Kirkbyidae the marginal flanges are set more or less at an angle to the surface of the carapace, and they extend to, or nearly to, the cardinal angles at each end, dying out as the cardinal angles are approached. Conversely, the frill of *Graphiodactylus* is confluent with the surface of the carapace along a large part of its length so that its true character can not be seen in lateral view. Moreover, instead of extending almost to the cardinal angles, the frill of *Graphiodactylus* begins about half way down the anterior margin and extends only to the post-ventral angle. Nothing resembling the prominent horn-like spine at the anterior end of the frill of *Graphiodactylus* is found in the Kirkbyidae. (4) The spines and papillae of *Graphiodactylus* are lacking on the Kirkbyidae. (5) The hinge and marginal structures are very different in the two families. In the Kirkbyidae it is the larger overlapping valve which carries the cardinal teeth, and the smaller valve the sockets. The opposite is true of *Graphiodactylus* in which the larger overlapping valve carries the sockets. Furthermore, the character of the teeth and sockets is entirely different in the two families. In the Kirkbyidae a maximum development of the cardinal processes, as in *A. rugosus* Girty, shows sharp and slender teeth which fit into small circular pit-like sockets. The teeth

of *Graphiodactylus*, on the other hand, are large, elongate and flange-like; and they fit into deep, elongate, triangular sockets, which are well shown in a photograph by Morey (1936, p. 116, pl. 17, fig. 21). In addition, *G. arkansanus* (Girty) and perhaps other species, show several very distinct but narrow crenulations on each cardinal tooth. These crenulations fit into shallow notches or depressions in the opposite socket which can best be seen by tilting the valve on end. On the right valve (usual orientation of the genus reversed) a groove runs along the hinge from the anterior tooth to the posterior of the hinge line, going above the posterior tooth. The lower edge of this groove was seen to be composed of fine bead-like teeth on one large specimen. The hinge of the left valve fits into the groove on the right; and the left valve very prominently overlaps the right in the region of the cardinal angles, completely covering the teeth of the smaller right valve. In contrast, the cardinal angles of *Amphissites rugosus* can be seen in interlock on the exterior of a closed carapace.

The similarity of the dentition of *Graphiodactylus* and that of the genus *Cytheropteron* and other post-Paleozoic genera gives rise to speculations as to their relationship. Although *Graphiodactylus* disappeared from the Mid-Continent region during Pennsylvanian time it is not known whether this disappearance was general, resulting in the complete extinction of the genus.

Because of the resemblance of *Graphiodactylus* to later genera of known orientation, the accepted orientation has been reversed so that the thicker end is the posterior.

The larger valve with the cardinal sockets is the left valve and the smaller valve with the cardinal teeth is the right.

Specimens of *G. arkansanus* (Girty) showing the above described crenulations and depressions of the cardinal teeth have been placed in the U. S. National Museum (no. 93635). They were collected by Mr. Ralph Brant of Tulsa from the Fayetteville shale, 1½ miles southwest of Locust Grove, Okla. This fauna contains a great number of well-preserved specimens of *G. arkansanus*, a study of which has brought out certain generic characteristics hitherto unnoted, such as the development of an inner calcareous lamella. This appears as a thin white ridge or line, the inner margin and the line of concresence coinciding. The calcareous lamella was studied only on the larger left valve, the interior of all of the right valves being covered with foreign material. This ridge of calcareous lamella coincides dorsally with the hinge line until it reaches the cardinal angles where it marks the lower wall of the triangular sockets and then continues around the valve at a little distance from the free margins marking the inner edge of the marginal depression which receives the opposite valve.

A number of neanic and ephebic molts of *G. arkansanus* occur in this fauna, some only about one-half the length of the gerontic molts. Intergrading series show that the striking "minute, bifurcating and inosculating riblets" present on most species of *Graphiodactylus* are not of first importance generically because they are replaced on the young of *G. arkansanus* by small reticulations or punctae. With progressive increase in the size of the carapaces these punctae become more linearly arranged and their walls coalesce until ridges typical of the adult are developed. As may be expected from the lack of riblets on the young of this Late Mississippian species, certain Early Mississippian species of *Graphiodactylus* such as *G. granopunctatus* Ulrich and Bassler lack the riblets and have only reticulations even on the largest adult molts. However, a few of the small punctate specimens which have been given specific names, such as *G. spinosus* Morey (1935, p. 321, pl. 28, fig. 6), are probably merely the immature molts of larger species with which they occur. In *G. arkansanus* the anterior marginal frill

and horn of the smallest specimens are much larger in proportion to the size of the valve than on the later molts. In addition to the small irregularly placed papillae on the posterior of the valve, the smallest specimens also exhibit a pair of conspicuous posterior spines placed much as on *Healdia*. With advancing age these spines become less conspicuous and, curiously, the lower one usually becomes either indistinct or absent on the later molts of this species, although the upper spine remains. Some of the largest molts have developed a row of short spines along the posterior margin of the valve. The ontogenetic series showing these changes has been deposited in the U. S. National Museum.

After instituting the genus *Graphiadactyllis*, Roth subsequently changed the spelling to *Graphiodactylus* because the genus was originally "improperly designated." The corrected transliteration is here somewhat doubtfully used in spite of Article 19 of the International Rules of Zoological Nomenclature which states that

> the original orthography of a name is to be preserved unless an error of transcription, a *lapsus calami*, or a typographical error is evident.

The question as to what constitutes an error of transcription has not been made sufficiently clear by the International Commission, and until this is settled the Editors of the Journal of Paleontology conclude that an erroneously transcribed (transliterated) term is emendable.

Genus WAYLANDELLA Coryell and Billings, 1934

WAYLANDELLA SPINOSA Coryell and Billings

Waylandella spinosa CORYELL and BILLINGS, *1932*, Am. Midland Naturalist, vol. 13, p. 175, pl. 17, fig. 7. (Type examined.)

Waylandella waylandica CORYELL and BILLINGS, *1932*, Am. Midland Naturalist, vol. 13, p. 175, pl. 17, fig. 8. (Type examined.)

Waylandella fornicata CORYELL and BILLINGS, *1932*, Am. Midland Naturalist, vol. 13, p. 176, pl. 17, fig. 6. (Type examined.)

The slight variations in length and the consequent variations in the curvature of the dorsal margins cannot be considered to be of specific importance in the above so-called species which were found occurring together in the Wayland shale, Graham formation, near Cisco, Texas. Such individual variations within a species are common not only in species of the closely related genera *Bythocypris* and *Healdia* but also in most other Carboniferous ostracode genera.

Genus CORYELLITES Kellett, n. name

Coryellina KELLETT, *1935*, Jour. Paleontology, vol. 9, p. 138, pl. 16, figs. *7a–c.*

Coryellites Kellett is here proposed as a new name for the genus *Coryellina* Kellett, preoccupied by *Coryellina* Bradfield, January, 1935.

Genus SEMINOLITES Coryell, 1928

SEMINOLITES TRUNCATUS Coryell

Seminolites truncatus CORYELL, *1928*, Jour. Paleontology, vol. 2, p. 88, pl. 11, fig. 1. Wewoka formation, Oklahoma. (Type examined.)—CORYELL and OSORIO, *1932*, Am. Midland Naturalist, vol. 13, p. 32. Nowata shale, Oklahoma.—CORYELL and BILLINGS, *1932*, Am. Midland Naturalist, vol. 13, p. 180, pl. 18, fig. 3. Wayland shale, Texas.

Seminolites elongatus CORYELL, *1928*, Jour. Paleontology, vol. 2, p. 88, pl. 11, fig. 2. Holdenville formation, Oklahoma. (Type examined.)—CORYELL and OSORIO, *1932*, Am. Midland Naturalist, vol. 13, p. 32. Nowata shale, Oklahoma.—CORYELL and BILLINGS, *1932*, Am. Midland Naturalist, vol. 13, p. 181, pl. 18, fig. 2. Wayland shale, Texas.

Seminolites extensus CORYELL, *1928*, Jour. Paleontology, vol. 2, p. 89, pl. 11, fig. 4. Francis formation, Oklahoma. (Type examined.)—CORYELL and OSORIO, *1932*, Am. Midland Naturalist, vol. 13, p. 32. Nowata shale, Oklahoma.

Seminolites compressus CORYELL, *1928*, Jour. Paleontology, vol. 2, p. 89, pl. 11, fig. 3. Francis formation, Oklahoma. (Type examined.)—CORYELL and BILLINGS, *1932*, Am. Midland Naturalist, vol. 13, p. 180, pl. 18, fig. 1. Wayland shale, Texas.

These forms of *Seminolites* which are regarded by Coryell as distinct species occur together. They differ only in the length to height ratio and in the number and distribution of the pits, all of which

slight differences appear in the light of further study to be matters of individual variation, age or sex. Harlton (1933, p. 26, pl. 7, figs. 6*a–c*) shows that the pits on *S. perforatus* from the lowermost Pennsylvanian vary greatly in position on different individuals and increase in number with age. It is probable that certain small specimens called *Healdia* which are quite low posteriorly are merely young examples of *Seminolites* in which the ridges and pits characteristic of the adult have not yet been developed.

Genus HEALDIA Roundy, 1926

HEALDIA CORYELLI Kellett, n. name

Healdia compressa KELLETT, *1935*, Jour. Paleontology, vol. 9, p. 142, pl. 16, figs. 1*a–l*.

The name *Healdia compressa* was preoccupied by Coryell and Billings, 1932. The new name *Healdia coryelli* Kellett is here proposed for the Kansas species in honor of Dr. H. N. Coryell, who first brought the error to my attention.

HEALDIA ELEGANS Warthin

Healdia elegans WARTHIN, *1930*, Okla. Geol. Survey, Bull. 53, p. 76, pl. 6, figs. 11*a*, *b*. Wetumka and Wewoka formations, Oklahoma. (Type examined.)—CORYELL and OSORIO, *1932*, Am. Midland Naturalist, vol. 13, p. 37. Nowata shale, Marmaton; Oklahoma.

Healdia arcuata CORYELL and OSORIO, *1932*, Am. Midland Naturalist, vol. 13, p. 37, pl. 5, fig. 6. Nowata shale, Oklahoma.

Family CYTHERELLIDAE G. O. Sars, 1865

Genus CAVELLINA Coryell, 1928, Emend. Kellett, 1935

CAVELLINA ARCUTA Coryell and Rogatz

Cavellina arcuata CORYELL and ROGATZ, *1932*, Am. Midland Naturalist, vol. 13, p. 389, pl. 34 (see explanation pl. 35), fig. 5. Arroyo formation, Texas. (Type examined.)

Cytherella molaris CORYELL and ROGATZ, *1932*, Am. Midland Naturalist, vol. 13, p. 389, pl. 34, fig. 6. Arroyo formation, Texas. (Type examined.)

Cavellina arcuata and *Cytherella molaris*, which occur together, are evidently the male and female variants of a rather small, short, species of *Cavellina*. *Cavellina arcuata* with its thick posterior is the female, and the thinner *Cytherella molaris* the male. The narrower posterior in side view of *Cytherella molaris* is quite typical of the male form of *Cavellina* (Kellett, 1935, pp. 144, 145, pl. 18, figs. 1*a–h*).

CAVELLINA MINIMA Coryell

Cavellina minima CORYELL, *1928*, Jour. Paleontology, vol. 2, p. 94, pl. 11, fig. 10, Wewoka and Holdenville formations, Oklahoma. (Type examined.)

Cavellina reversa CORYELL, *1928*, Jour. Paleontology, vol. 2, p. 92, p. 11, fig. 7. Boggy shale, Oklahoma. (Type examined.)

From a comparison of the holotypes and other material, *C. reversa* is apparently conspecific with *C. minima* which is fairly common in the Lower Pennsylvanian rocks of Oklahoma, and is characterized by being small and thick. The holotype is not quite so elongate as figured.

CAVELLINA ROBUSTA Bradfield

Cavellina robusta BRADFIELD, *1935*, Bull. Am. Paleontology, vol. 22, no. 73, p. 129, pl. 11, figs. 18*a*, *b*. Jolliff limestone, lower Dornick Hills formation; southern Oklahoma.

Cytherella jolliffana BRADFIELD, *1935*, Bull. Am. Paleontology, vol. 22, no. 73, p. 122, pl. 10, figs. 16*a*, *b*. Jolliff limestone, lower Dornick Hills formation; southern Oklahoma.

Cavellina subovata HARLTON (not Coryell), *1933*, Jour. Paleontology, vol. 7, p. 27, pl. 7, fig. 11. Johns Valley shale, southern Oklahoma. (Type examined.)

Cavellina lata HARLTON (not Coryell), *1933*, Jour. Paleontology, vol. 7, p. 27, pl. 7,fig. 12. Johns Valley shale, southern Oklahoma. (Type examined.)

Bradfield notes that *Cytherella jolliffana* may be the male of *Cavellina robusta*, which I think is true. He believes, however, that the correct linking of the respective male and female forms of species of *Cavellina* is almost impossible and that any attempt to do so would only "result in endless confusion." Nevertheless, Van Veen and Alexander in their work with the post-Paleozoic Cytherellidae have correctly identified

the male and female forms of a large number of cytherelloid species. I see no reason why, with care and time, the male and female forms of most species of *Cavellina* should not be correctly associated.

The two specimens described by Harlton from the lowermost Pennsylvanian as *C. subovata* Coryell and *C. lata* Coryell are both decidedly larger and more broadly rounded at the ends than the species much higher in the section to which they are referred. These two forms are conspecific, and are tentatively referred to Bradfield's large species *C. robusta* from about the same horizon, the types of which I have not examined however.

Family ENTOMOCONCHIDAE Brady, 1868

I have previously (Kellett, 1935, p. 154) incorrectly credited the family name Entomoconchidae to Ulrich, 1900. Dr. H. N. Coryell kindly brought to my attention the fact that this name was used by Brady as early as 1868.

Genus OFFA Jones and Kirkby, 1874

OFFA PERMINUTA (Kellett)

Paraparchites (?) *perminutus* KELLETT, *1933*, Jour. Paleontology, vol. 7, p. 67, pl. 13, figs. 31, 32. Iatan limestone to Emporia limestone, Kansas.

Offa perminuta KELLETT, 1935, Jour. Paleontology, vol. 9, p. 154.

Offa (?) *perminuta* JOHNSON, *1936*, Nebr. Geol. Survey, Paper 11, pp. 48, 49, pl. 5, fig. 10. Kansas City group, Nebraska.

Schmidtella (?) sp. BRADFIELD, *1935*, Bulletin Am. Paleontology, vol. 22, no. 73, p. 139, pl. 13, figs. 9*a*, *b*. Lester limestone, upper Dornick Hills formation; Oklahoma.

The specimen found by Bradfield is undoubtedly congeneric with *Offa perminuta* and very probably conspecific, although the specimens found by both Bradfield and Johnson are slightly larger than those found higher in the Pennsylvanian. These shells of *Offa* are commonly found in the Lower Pennsylvanian in deep wells and seem gradually to increase in size with increasing depth at which they are found, showing the maximum size in the formations of Marmaton and Cherokee age.

FAUNA OF THE ST. LOUIS PENNSYLVANIAN OUTLIER

Eight years ago Knight published an article on the ostracode fauna from the Pennsylvanian outlier of St. Louis and of St. Louis County, Missouri. Later he collected from the same area, and six additional species of ostracodes were found. Doctor Knight and Doctor Moore very kindly loaned me Knight's original types as well as the newly collected material. A study of these ostracodes in the light of our increased knowledge as to the great variations within species has necessitated some additions and corrections to Knight's work in which Knight concurs. Furthermore, various authors have erected new genera in which a number of the Missouri species have been placed. Specimens of the species not listed by Knight have been sent to the U. S. National Museum.

Knight's correlation of the St. Louis outlier with the standard Missouri section is correct, but certain changes later made by Green (1933) in the Missouri section have necessitated slight changes in the nomenclature of some of Knight's horizons. The fauna is all from the Henrietta formation of Missouri (lower Marmaton of the Kansas Survey), Des Moines series. Knight now calls the "upper Fort Scott limestone" of his original work the "brown limestone" of the Labette shale. This bed is in the cap-rock of the Lexington coal, or simply Lexington cap-rock of some Mid-Continent geologists. The Labette shale lies above the upper Fort Scott limestone and below the Pawnee limestone. The original correlation of the Pawnee limestone appears to be correct. In the following corrected list the additional species have been added and the generic and stratigraphic names brought up to date.

Ostracodes of the St. Louis Pennsylvanian Outlier

Paraparchites latidorsatus Warthin, rare in the "brown limestone" of the Labette shale, Loc. 38.

Paraparchites claytonensis Knight, Pawnee limestone, Loc. 6.

Paraparchites laduensis Knight, "brown limestone", Loc. 38.

Ardmorea (?) gibberosa (Knight), very rare in the Pawnee limestone, Loc. 6.

Hollinella bassleri (Knight), common in the "brown limestone" at Locs. 2, 38 and 47.

Hollinella kellettae Knight, "brown limestone," Locs. 2 and 38.

Geisina gregaria (Ulrich and Bassler), common in the "brown limestone" at Locs. 38 and 47. Questionably found in the Pawnee limestone at Loc. 6.

Geisina arcuata (Bean), rare in the "brown limestone" at Locs. 2, 38 and 47.

Kellettina montosa (Knight), common in the "brown limestone" at Loc. 38, present also at Loc. 2. (Swartz, 1936, pp. 577, 585).

Kirkbya voluta Knight, rare in the "brown limestone" at Loc. 38.

Kirkbya laciniata Knight, rare in the "brown limestone" at Locs. 38 and 13.

Kirkbya scaphula Knight, "brown limestone," Loc. 38.

Kirkbya aff. *pergrandis* Kellett, rare in the Pawnee limestone, Loc. 6.

Amphissites centronotus (Ulrich and Bassler), abundant in the "brown limestone" at Loc. 38, found also at Locs. 2, 12, 13, and 47. Present also in the upper 2 feet of the Labette shale at Loc. 43.

Amphissites girtyi Knight, common in the "brown limestone" at Loc. 38, found also at the same horizon at Locs. 2 and 47.

Amphissites roundyi Knight, "brown limestone" at Locs. 2, 37, 38, and 47.

Amphissites pinguis (Ulrich and Bassler), rare in the "brown limestone" at Locs. 38 and 47.

Knightina allerismoides (Knight), "brown limestone," abundant at Locs. 38 and 47, rarer at Loc. 22.

Roundyella simplicissimus (Knight), "brown limestone," abundant at Loc. 38 and rare at Loc. 37.

Bairdia beedei Ulrich and Bassler, "brown limestone" at Locs. 38, 2 and 47.

Bairdia oklahomaensis Harlton, rare in the "brown limestone", at Loc. 38.

Bairdia seminalis Knight, rare in the Pawnee limestone at Loc. 6, upper 2 feet of the Labette shale at Loc. 43; "brown limestone" at Locs. 2, 13, 38; upper Fort Scott limestone at Locs. 7, 9, 12 and 28.

Bairdia citriformis Knight, abundant in the lower 2 feet of the Pawnee limestone at Loc. 6.

Bairdia pompilioides Harlton, Pawnee limestone, Loc. 6.

Bairdia altifrons Knight, rare in the "brown limestone" at Loc. 38.

Bairdia hoxbarensis Harlton, rare in the "brown limestone" at Locs. 38 and 2.

Bairdia glennensis Harlton, rare in the Pawnee limestone at Loc. 6.

Bairdia blakei Harlton, rare in the Pawnee limestone at Loc. 6.

Bythocypris pediformis Knight, common in the "brown limestone" at Locs. 38 and 47, rarer at Locs. 2 and 13.

Basslerella (?) rostrata (Knight), Pawnee limestone at Loc. 6.

Healdia nuceolata Knight, "Brown limestone," Locs. 2, 38 and 47. Abundant at Loc. 38.

Healdia limacoidea Knight, common in the "brown limestone" at Locs. 13 and 38.

Cavellina pulchella Coryell, common in the brown limestone" at Locs. 38 and 47.

Silenites lenticularis (Knight), Pawnee limestone, Loc. 6; rare in the "brown limestone" at Loc. 38.

Moorites (?) minutus (Warthin), rather rare in the "brown limestone" at Loc. 38.

Cyathus ulrichi Roth and Skinner, rare in the Pawnee limestone at Loc. 6.

Family LEPERDITELLIDAE Ulrich and Bassler, 1906

Genus PARAPARCHITES Ulrich and Bassler, 1906

PARAPARCHITES LATIDORSATUS Warthin

Paraparchites latidorsatus WARTHIN, *1930*, Okla. Geol. Survey, Bull. 53, p. 55, pl. 4, figs. 1*a*, *b*. Wetumka to Holdenville formations, Oklahoma. (Type examined.)—CORYELL and SAMPLE, *1932*, Am. Midland

Naturalist, vol. 13, p. 249, pl. 24, fig. 2. East Mountain shale, Texas.

Paraparchites cuneatus WARTHIN, *1930*, Okla. Geol. Survey, Bull. 53, p. 56, pl. 4, figs. 2*a*, *b*. Wewoka and Holdenville formations, Oklahoma. (Type examined.)

Two specimens of *P. latidorsatus* Warthin occurred in the "brown limestone" at Knight's locality 38. Although *P. latidorsatus* and *P. cuneatus* do not have quite the same appearance, the smaller *P. cuneatus* is evidently an early molt of *P. latidorsatus* as they usually occur together and intergrading forms are always present wherever there are many specimens. The oblique antero-ventral angle of *P. cuneatus* is quite characteristic of the young of many species of *Paraparchites*, in contrast to the more rounded antero-ventral angle of the adult (see the ontogenetic series of *P. humerosus*, Kellett, 1933, pl. 13, figs. 1–12). One of the specimens found in Knight's material is small and resembles the form figured by Warthin as *P. cuneatus*. U. S. Nat. Mus., no. 93528.

PARAPARCHITES CLAYTONENSIS Knight

Paraparchites claytonensis KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 231, pl. 31, figs. 8*a–d*.

Large specimens of *P. claytonensis* show a very distinct beveling of the larger right valve along the venter and half way up the ends, into which fits the smaller left valve.

Family HOLLINIDAE Swartz, 1936

Genus HOLLINELLA Coryell, 1928; Emend. Kellett, 1929

HOLLINELLA BASSLERI Knight

Hollina bassleri KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 240, pl. 31, fig. 3; pl. 34, fig. 7.

Hollina buehleri KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 236, pl. 31, fig. 1; pl. 34, fig. 8.

Hollina fortscottensis KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 237, pl. 31, fig. 2.

Hollinella bassleri KELLETT, *1929*, Jour. Paleontology, vol. 3, p. 197, pl. 25, figs. 5*a–c*.

Other specimens have been referred to *H. bassleri* but I have not examined the types which I believe is necessary for positive identification in this genus.

HOLLINELLA KELLATTAE Knight

Hollina ulrichi KNIGHT, *1928*, (the Lower Pennsylvanian but not the Kansas Permian specimens), Jour. Paleontology, vol. 2, p. 237, pl. 31, figs. 4*a*, *b*.

Hollinella kellettae KELLETT, *1933*, Jour. Paleontology, vol. 7, p. 70.—CORYELL and BOOTH, *1933*, Am. Midland Naturalist, vol. 15, p. 271, pl. 5, figs. 8–10.—SCHUCHERT and DUNBAR, *1933*, Textbook of Geology, pt. 2, Historical Geology, p. 269, text-fig. 156 (13). (Not a copy of the original fig. but a new drawing.)

Johnson (1936, pp. 13–15) believes *H. kellettae* to be conspecific with the Permian *H. ulrichi* Knight. Although he may be correct in saying that the number of papillae is not of specific importance, nevertheless it seems to me that the two forms should be differentiated because the anterior node of the Lower Pennsylvanian *H. kellettae* is never bulbous like that of the Permian *H. ulrichi*, the former being not much more than hemispherical in its maximum development.

The reference by Johnson of *H. gibbosa* Kellett to *H. ulrichi* Knight with which it often occurs is probably correct, for *H. gibbosa* differs only in the lack of the papillae found on *H. ulrichi*. At several horizons I have found other non-papillate species with their corresponding papillate forms. It seems that perhaps certain species developed many papillae when the calcium carbonate content of the water was high and few or no papillae when it was low. However, some species of *Hollinella* apparently lack the ability to develop the papillae even under the most favorable conditions, as the only papillate specimens with which they occur are clearly specifically distinct.

Family KLOEDENELLIDAE Ulrich and Bassler, 1923

Genus GEISINA Johnson, 1936

GEISINA GREGARIA (Ulrich and Bassler)

Beyrichiella gregaria ULRICH and BASSLER,

1906, U. S. Nat. Mus., Proc., vol. 30, p. 157, pl. 11, fig. 18.

Jonesina gregaria (ULRICH and BASSLER), *1908*, U. S. Nat. Mus., Proc., vol. 35, pl. 44, fig. 6.—KNIGHT, *1928*, Jour. Paleontology, vol. 2, pp. 241–243, pl. 31, figs. 5*a–f*.

Geisina gregaria JOHNSON, *1936*, Nebr. Geol. Survey, Paper 11, p. 22, pl. 2, figs. 11–14. (More nearly complete synonomy given in this paper.)

GEISINA ARCUTA (Bean), n. comb.

Cypris arcuata BEAN, *1836*, Annals and Mag. Nat. Hist., vol. 9, p. 377, fig. 55.

Jonesina arcuata (Bean). ULRICH and BASSLER, *1908*, U. S. Nat. Mus., Proc., vol. 35, pl. 44.—KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 243, pl. 31, figs. 6*a, b;* pl. 33, fig. 6. (More nearly complete synonymy given here.)

Family KIRKBYIDAE Ulrich and Bassler, 1923

Genus KIRKBYA Jones, 1859, Emend. Knight, 1928

KIRKBYA CLAROCARINATA Knight

Kirkbya clarocarinata KNIGHT, *1928*, Jour. Paleontology, vol. 2, pp. 258, 259, pl. 32, fig. 2; pl. 33, fig. 2. (For synonymy see BASSLER and KELLETT, *1934*, Bibl. Index Paleozoic Ostrocoda, p. 351.)—JOHNSON, *1936*, Nebr. Geol. Survey, Paper 11, pp. 25, 26, pl. 3, figs. 22–24 [?].

(not) *Kirkbya punctata* KELLETT, *1933*, Jour. Paleontology, vol. 7, p. 87, pl. 14, figs. 46–49.

(not) *Kirkbya valida* KELLETT, *1933*, Jour. Paleontology, vol. 7, p. 86, pl. 14, figs. 11, 12.

Although Johnson regards *K. punctata* and *K. valida* as synonyms of *K. clarocarinata*, I do not believe that they are conspecific, for besides differences in size and shape *K. clarocarinata* has a large circular muscle pit while both of the other species have small, elongate oval muscle pits. Johnson disregards the character of the pits, saying that they are variable and "not of specific importance." Nevertheless I believe that the kirkbyian pits are established in their value as taxonomic criteria. In a fauna from my Loc. 25 there were about 50 specimens of *K. valida*, including molts of all ages, and the small, elongate oval muscle pit was constant in all sizes. I have also seen many specimens of *K. clarocarinata* from several horizons, including Harlton's Menard County material, and the muscle spot is always circular even in the smaller specimens.

KIRKBYA aff. PERGRANDIS Kellett

Kirkbya pergrandis KELLETT, *1933*, Jour. Paleontology, vol. 7, p. 85, pl. 14, fig. 31.

Two broken specimens resembling *K. pergrandis* Kellett were found in the Pawnee limestone at Knight's Loc. 6. They are smooth and very large, but differ from *K. pergrandis* in having a very narrow flange. The muscle spot cannot be seen on one of the specimens, but on the other it is very large, shallow and almost circular. U. S. Nat. Mus. no. 93529.

Genus KNIGHTINA Kellett, 1933

KNIGHTINA ALLERISMOIDES (Knight)

Amphissites allerismoides KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 265, pl. 32, figs. 10*a–c;* pl. 34, fig. 4.

Knightina allerismoides KELLETT, *1933*, Jour. Paleontology, vol. 7, pp. 97, 98.—JOHNSON, *1936*, Nebr. Geol. Survey, Paper 11, pp. 33, 34.

K. allerismoides was described as having three rows of reticulation pits between the flanges. However, of 50 specimens collected by Knight about 10 of them had only two rows of reticulation pits between the flanges. Nevertheless, these specimens with only two rows of reticulation pits can be differentiated from *K. texana* Harlton by the more rounded post-dorsal angle and the less blunt anterior of the latter.

Genus ROUNDYELLA Bradfield, 1935

ROUNDYELLA SIMPLICISSIMUS (Knight)

Amphissites simplicissimus KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 266, pl. 32, figs. 11*a–d*; pl. 34, fig. 6.

Roundyella simplicissimus BRADFIELD, *1935*, Bull. Am. Paleontology, vol. 22, no. 73, p. 66.—JOHNSON, *1936*, Nebr. Geol. Survey, Paper 11, pp. 32, 33, pl. 3, figs. 7, 8. Lansing group, Kansas.

Family BAIRDIIDAE G. O. Sars, 1887

Genus BAIRDIA McCoy, 1844

BAIRDIA BEEDEI Ulrich and Bassler

Bairdia beedei ULRICH and BASSLER, *1906*,

U. S. Nat. Mus., Proc., vol. 30, p. 161, pl. 11, figs. 19–22. "Cottonwood shales," Permian; Kansas.—KELLETT, *1934*, Jour. Paleontology, vol. 8, p. 128, pl. 14, figs. 1*a–h*. (B. *moorei* placed in synonymy of *B. beedei*. (A more complete synonymy of *B. beedei* is also found in this publication.)

Bairdia moorei KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 318, pl. 43, figs. 1*a–c*.

Bairdia hurwitzi CORYELL and BOOTH, *1933*, Am. Midland Naturalist, vol. 14, p. 262, pl. 3, figs. 8, 9. (Topotypes examined.)

Bairdia marmorea JOHNSON, *1936*, Nebr. Geol. Survey, Paper 11, pp. 38, 39, pl. 4, figs. 1, 2.

BAIRDIA OKLAHOMAENSIS Harlton

Bairdia oklahomaensis HARLTON, *1927*, Jour. Paleontology, vol. 1, p. 209, pl. 33, fig. 7.—HARLTON, *1929*, Texas Univ., Bull. 2901, p. 156, pl. 3, figs. 5*a*, *b*.—JOHNSON, *1936*, Nebr. Geol. Survey, Paper 11, p. 41, pl. 4, figs. 6, 7.

Bairdia auricula KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 319, pl. 43, figs. 3*a*, *b*.—WARTHIN, *1930*, Okla. Geol. Survey, Bull. 53, p. 68, pl. 5, figs. 5*a*, *b*.—CORYELL and OSORIO, *1932*, Am. Midland Naturalist, vol. 13, p. 34.—CORYELL and SAMPLE, *1932*, Am. Midland Naturalist, vol. 13, p. 263, pl. 25, fig. 6.

(not) *Bairdia dornickhillensis* HARLTON, *1929*, Am. Jour. Sci., 5th ser., vol. 18, p. 268, pl. 2, fig. 12.—BRADFIELD, *1935*, Bull. Am. Paleontology, vol. 22, no. 73, p. 78, pl. 5, figs. 3*a*, *b*.—KELLETT, *1935*, Jour. Paleontology, vol. 9, footnote on page 135.

Even after *B. auricula* was placed in the synonomy of *B. oklahomaensis* by Harlton in 1929 other authors have erroneously continued to differentiate the two in first one way and then another on the basis of what are merely individual variations. Knight had seen only the very poor type figure and not the holotype of *B. oklahomaensis* when he established the species *B. auricula*, and now agrees with Harlton that *B. auricula* is conspecific with *B. oklahomaensis*. This is confirmed by my own study of not only the holotype but of numerous specimens of this species, which is common in the Missouri series of Kansas, Oklahoma and Texas. The large *B. auricula* figured by Bradfield, 1935, is probably misidentified; the figure resembles rather *B. garrisonensis* Upson (1933, p. 20, pl. 1, figs. 10*a–c*) in size and shape (Kellett, 1934, p. 134, pl. 17, figs. 5*a–c*).

BAIRDIA POMPILIOIDES Harlton

Bairdia pompilioides HARLTON, *1928*, Jour. Paleontology, vol. 2, p. 140, pl. 21, fig. 13.—HARLTON, *1929*, Texas. Univ., Bull. 2901, pl. 2, fig. 7; pl. 3, fig. 8. (*B. subcitriformis* placed in synonymy of *B. pompilioides*.)

Bairdia subcitriformis KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 322, pl. 43, figs. 5*a*, *b*.

BAIRDIA HOXBARENSIS Harlton

Bairdia hoxbarensis HARLTON, *1927*, Jour. Paleontology, vol. 1, p. 211, pl. 33, figs. 12. (*not* Harlton, *1929*, Texas Univ., Bull, 2901, p. 154, pl. 3, figs. 1*a–d*).—KELLETT, *1934*, Jour. Paleontology, vol. 8, p. 131, pl. 16, figs. 5*a–c*. (Synonymy given in this reference.)—JOHNSON, *1935*, Nebr. Geol. Survey, Paper 11, pp. 40, 41, pl. 4, fig. 8.

B. haworthi KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 325, pl. 43, figs, 7*a*, *b*.

B. subelongata KNIGHT (not Jones and Kirkby), *1928*, Jour. Paleontology, vol. 2, p. 236, pl. 43, fig. 9.

BAIRDIA BLAKEI Harlton

Bairdia nitida HARLTON, *1928*, Jour. Paleontology, vol. 2, p. 139, pl. 21, fig. 12. Hoxbar formation, Okla. (Type examined.)—HARLTON, *1929*, Univ. Texas, Bull. 2901, p. 155, pl. 3, figs. 3*a*, *b*. Graham formation, Texas. (Type examined.)—WARTHIN, *1930*, Okla. Geol. Survey, Bull. 53, p. 72, pl. 6, figs. 3*a*, *b*. Holdenville formation, Okla. (Type not examined.)

Bairdia blakei HARLTON, *1931*, Jour. Paleontology, vol. 5, p. 163. (New name for *B. nitida* Harlton preoccupied, 1879, by Jones and Kirkby.)—CORYELL and OSORIO, *1932*, Am. Midland Naturalist, vol. 13, p. 34. Nowata shale, Marmaton, Oklahoma. (Type not examined.)

Three specimens of *B. blakei* were found in the Pawnee limestone at Knight's Loc. 6. (U. S. Nat. Mus. no. 93530.) The specimen called *B. blakei* by Bradfield appears to be, from the figure, the common *B. seminalis* Knight.

BYTHOCYPRIS PEDIFORMIS Knight

Bythocypris pediformis KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 36, pl. 44, figs. 3*a–c*.—KELLETT, *1935*, Jour. Paleontology, vol. 9, p. 135, pl. 16, figs. 8*a–f*. (A number of other references and synonyms are given in this paper.)—JOHNSON, *1936*, Nebr. Geol. Survey, Paper 11, p. 43, pl. 4, figs. 13–15.

Bythocypris parallela KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 327, pl. 44, figs. 2*a*, *b*.—WARTHIN, *1930*, Okla. Geol. Survey, Bull. 53, p. 74, pl. 6, figs. 6*a*, *b*. (*B. parallela* referred to *B. pediformis* for first time.)

Healdia leguminoidea KNIGHT, *1928*, Jour. Paleontology, vol. 26, p. 332, pl. 44, figs. 7*a*, *b*.

Bythocypris deesensis BRADFIELD, *1935*, Bull. Am. Paleontology, vol. 22, no. 73, p. 95, pl. 7, figs. 12*a*, *b*.

Bythocypris simillima BRADFIELD, *1935*, Bull. Am. Paleontology, vol. 22, no. 73, p. 96, pl. 7, figs. 10*a*, *b*.

Bythocypris angularis BRADFIELD, *1935*, Bull. Am. Paleontology, vol. 22, no. 73, p. 97, pl. 7, figs. 14*a*, *b*.

Bythocypris cookei BRADFIELD, *1935*, Bull. Am. Paleontology, vol. 22, no. 73, p. 97, pl. 8, figs. 1*a*, *b*.

Bythocypris hoxbarana BRADFIELD, *1935*, Bull. Am. Paleontology, vol. 22, no. 73, p. 101, pl. 8, figs. 8*a*, *b*.

Bythocypris subpediformis BRADFIELD, *1935*, Bull. Am. Paleontology, vol. 22, no. 73, p. 102, pl. 8, figs. 9*a*, *b*.

An examination of the types of *Healdia leguminoidea* Knight as well as a study of intergrading series of other specimens show that the types are merely very early molts of *B. pediformis*.

B. pediformis is a very common and long-ranging species and shows many slight variations in outline which have erroneously been employed as the basis for specific names. Altogether *B. pediformis* has been divided into twelve different species by authors. Bradfield, in faunas from the Deese and Hoxbar formations alone, divides *B. pediformis* into nine different species, none of which are over 0.65 mm. in length. These nine species include, besides *B. pediformis* and six new species, *B. parallela* and *B. scapha* Coryell and Billings. The latter two species have been already referred to *B. pediformis*. All of these so-called species could be found in any fair-sized collection of *B. pediformis* from the Lower Pennsylvanian to the Permian. They are based on very slight variations in size, outline and amount of overlap, which differences are due to age, preservation, individual variation, and perhaps to sex (Wilson, 1933, p. 419).

HEALDIA NUCLEOLATA Knight

Healdia nucleolata KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 329, pl. 44, figs. 4*a*–*c*.

H. nucleolata is very common at Knight's Loc. 38. As may be expected in a number of *Healdia* of any one species, there can be found two more or less distinct forms, one form more elongate than the other (Kellett, 1935, p. 141, pl. 16, figs. 1*a*–1*l*, 2*a*–2*e*, 5*a*–5*d*). The specimen illustrated and described by Knight is typical of the higher form. The other has about the same length but is not so high, and consequently the dorsum is only slightly curved. Both lack spines but show the posterior ridge. Topotypes, U. S. Nat. Mus., no. 93531.

HEALDIA LIMACOIDEA Knight

Healdia limacoidea KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 33, pl. 44, figs. 5*a*–*c*.—WILSON, *1933*, Jour. Paleontology, vol. 7, p. 421, pl. 50, figs. 1*a*–*d*. McAlester shale, Oklahoma.

Healdia longa KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 332, pl. 44, figs. 6*a*–*c*.—WARTHIN, *1930*, Okla. Geol. Survey, Bull. 53, p. 75, pl. 6, figs. 10*a*, *b*. Wewoka formation, Oklahoma. (Type not examined.)—CORYELL and SAMPLE, *1932*, Am. Midland Naturalist, vol. 13, p. 270, pl. 24, fig. 5. (Type not examined.) East Mountain shale, upper Strawn; Texas.—WILSON, *1933*, Jour. Paleontology, vol. 7, p. 241. McAlester shale, Oklahoma.

Healdia formosa WARTHIN (not Harlton), *1930*, Okla. Geol. Survey, Bull. 53, p. 77, pl. 6, figs. 13*a*, *b*. Wewoka formation, Oklahoma. (Type examined.)—CORYELL and OSORIO, *1932*, Am. Midland Naturalist, vol. 13, p. 37. Nowata shale, Marmaton; Oklahoma.—CORYELL and SAMPLE, *1932*, Am. Midland Naturalist, vol. 13, p. 270, pl. 26, fig. 7. East Mountain shale, Texas.—BAILEY, *1935*, Jour. Paleontology, vol. 9, p. 489. Des Moines group, central Missouri.

Although *H. formosa* Harlton and *H. limacoidea* Knight are two quite distinct species, many authors seem to have confused them. An examination of Harlton's type and other specimens from the type locality shows *H. formosa* to be a very large *Healdia* with a length of 1.10 mm. and with very stout, long spines, their length being not exaggerated in the type figure. *H. limacoidea*, on the other hand,

is much smaller than *H. formosa*, having a maximum length of only 0.74 mm., and with considerably shorter and less conspicuous spines as shown in the figure by Wilson. The specimen photographed by Knight shows the maximum development of spines on this species. The specimens referred by later authors to *H. formosa* Harlton are all more than a third shorter than Harlton's type, none of them exceeding 0.70 mm. in length, and none show very long spines. Therefore they belong to *H. limacoidea* or a similar small species rather than to the large, very long-spined *H. formosa* which probably occurs lower in the section.

H. longa should be referred to *H. limacoidea*, with which it occurs, as the more elongate variant of this species. Intermediate forms are found between the two types, and elongate specimens like *H. longa* are found with spines. Furthermore, the types of *H. longa* are both very poor specimens, one badly mashed and the other weathered.

SILENITES LENTICULARIS (Knight)

Carbonia (?) *lenticularis* KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 335, pl. 44, figs. 9*a*, *b*.

Silenites lenticularis KELLETT, *1935*, Jour. Paleontology, vol. 9, p. 151, pl. 17, figs. 9*a–i*. (Several other synonyms of *S. lenticularis* are given here.)—JOHNSON, *1936*, Nebr. Geol. Survey, Paper 11, p. 44, pl. 4, fig. 12.

The types of *S. lenticularis* were weathered, immature specimens, so several much better specimens from Knight's material have been sent to the U. S. Nat. Mus., no. 93532.

Family CYTHERELLIDAE G. O. Sars, 1865

Genus CAVELLINA Coryell, 1928; Emend. Kellett, 1935

CAVELLINA PULCHELLA Coryell

Cavellina pulchella CORYELL, *1928*, Jour. Paleontology, vol. 2, p. 94, pl. 11, fig. 5.—KELLETT, *1935*, Jour. Paleontology, vol. 9, p. 145. (*Cytherella missouriensis* and other species are here given as synonyms of *Cavellina pulchella*).

Cytherella missouriensis KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 334, pl. 44, figs. 8*a–i*.

Family YOUNGIELLIDAE Kellett, 1933

Genus MOORITES Coryell and Billings, 1932

MOORITES MINUTUS (Warthin)

Glyptopleurina (?) *minuta* WARTHIN, *1930*, Okla. Geol. Survey, Bull. 53, p. 67, pl. 5, fig. 6.

Moorites minutus CORYELL and SAMPLE, *1932*, Am. Midland Naturalist, vol. 13, p. 183, pl. 18, fig. 6.—CORYELL and SAMPLE, Am. Midland Naturalist, vol. 13, p. 256, pl. 24, fig. 18.—KELLETT, *1933*, Jour. Paleontology, vol. 7, p. 104, pl. 14, figs. 37–39 (other synonyms given in this article); *1935*, Jour. Paleontology, vol. 9, p. 163.—JOHNSON, *1936*, Nebr. Geol. Survey, Paper 11, p. 37, pl. 3, figs. 20, 21.

Youngiella minuta WILSON, *1933*, Jour. Paleontology, vol. 7, pp. 414–416.

Six specimens of *Moorites* (?) *minutus* were found in the "brown limestone" of the Labette shale at Knight's Loc. 38. As shown by Wilson there is some question as to the validity of the genus *Moorites*. *M. minutus* occurs in Early and Middle Pennsylvanian strata from Texas to Nebraska. U. S. Nat. Mus., no. 93533.

Family CYTHERIDAE Baird, 1850

Genus BASSLERELLA Kellett, 1935

BASSLERELLA (?) ROSTRATA (Knight)

Bythocypris (?) *rostrata* KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 328, pl. 44, figs. 1*a–c*.

Bairdianella rostrata (Knight) BASSLER and KELLETT, *1934*, Bibl. Index Paleozoic Ostracoda, p. 182.

Basslerella (?) *rostrata* KELLETT, *1935*, Jour. Paleontology, vol. 9, p. 156.

Family Unknown

Genus ARDMOREA Bradfield, 1935

ARDMOREA (?) GIBBEROSA (Knight)

Aechmina (?) *gibberosa* KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 235, pl. 31, figs. 9*a*, *b*.

Ardmorea gibberosa BRADFIELD, *1935*, Bull. Am. Paleontology, vol. 22, no. 73, p. 139, pl. 13, figs. 4*a*, *b*. Confederate limestone,

basal Hoxbar formation; near Ardmore, Oklahoma.

Not having examined the genotype of *Ardmorea* (*A. symmetrica* Bradfield) I am not at all sure that *Aechmina? gibberosa* should be referred to this genus. *A. (?) gibberosa* is of some stratigraphic value as it is found nowhere above the Missouri series.

Genus CYATHUS Roth and Skinner, 1930

CYATHUS ULRICH Roth and Skinner

Cyathus ulrichi ROTH and SKINNER, *1930*, Jour. Paleontology, vol. 4, pp. 234, 337, pl. 28, figs. 508. McCoy formation, Lower Pennsylvanian; Colorado.—KELLETT, *1933*, Jour. Paleontology, vol. 7, p. 69, pl. 13, figs. 27–29. Stanton formation, Middle Pennsylvanian; Kansas; *1935*, Jour. Paleontology, vol. 9, p. 163. Lower Permian, Kansas.

One specimen of *Cyathus ulrichi* Roth and Skinner was found in the Pawnee limestone at Knight's Loc. 6, zone 15. U. S. Nat. Mus. no. 93534.

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BETTY KELLETT (MRS. E. H. NADEAU), 503 EDGINGTON APTS., WICHITA, KAN. MANUSCRIPT RECEIVED BY THE EDITOR, AUGUST 10, 1936.

PALEONTOLOGICAL NOTES

OCCURRENCE OF *NONIONELLA COCKFIELDENSIS* AT CLAIBORNE, ALABAMA

J. B. GARRETT, JR.

Claiborne Bluff has long been famous, both as a historic fossil locality and as the type outcrop of the Claiborne group. Further, in a single exposure the Jackson group is to be found overlying the Claiborne. Logically, therefore, a study of the relationship between upper Claiborne and lower Jackson may well begin here. I have had the opportunity to examine the microfaunas of a series of samples collected at Claiborne Bluff by the late Karl E. Young. The samples were taken from the various beds distinguished by Cooke (1926), part of whose section follows.

Section at Claiborne Bluff, Alabama River (after Cooke)

	Feet
Pleistocene	
14. Sand, pebbles, and red loam of variable thickness	35–40
Eocene	
Ocala limestone	
13. Argillaceous white limestone with grains of glauconite	45
12. "*Scutella* bed"; light-colored calcareous materials holding great numbers of *Periarchus lyelli* Conrad	3
11. Coarse ferruginous sand with glauconite, passing below into more calcareous material which is indurated and projects from the face of the bluff	6
Claiborne group	
Gosport sand	
10. Ferruginous sand, holding vast numbers of shells; near the center of this sand there are in places thin bands of lignite, and along the ferry road the upper part of it is composed of laminated gray clays filled with impressions of leaves	15–17
Lisbon formation	
9. Bluish-green, glauconitic, sandy marl, with *Ostrea sellaeformis*, generally somewhat indurated above, and forming a hard projecting ledge	3–4
8. Calcareous clay or clayey marl gray when dry but blue when wet; it contains a few chalky fossils; this bed becomes sandier below, as well as glauconitic and highly fossiliferous, the principal shells being *Ostrea sellaeformis* and *Pecten* sp.	18

It was with considerable interest that I noted the occurrence in Beds 11 and 12 of *Nonionella cockfieldensis*, heretofore reported from the surface only in Texas (Cushman and Ellisor, 1933). Especially intriguing was its existence in the well-known "*Scutella* bed." Somewhat less interesting was its absence in Bed 10. The other microfossils present in Beds 11 and 12 bear a definite lower Jackson aspect, as may be seen from the following list.

Microfauna from Beds 10 and 11 at Claiborne Bluff

FORAMINIFERA

Textularia dibollensis Cushman and Applin
Textularia mississippiensis Cushman
Textularia recta Cushman
Textularia sp.
Quinqueloculina longirostra d'Orbigny
Spiroloculina grateloupi D'Orbigny
Miliola saxorum Lamarck
Robulus alato-limbatus (Gumbel)
Robulus propinquus (Hantken)
Robulus sp.
Planularia truncana (Gumbel)
Marginulina sp.
Dentalina hantkeni Cushman
Nodosaria fissicostata (Gumbel)
Nodosaria latejugata Gumbel
Nodosaria vertebralis (Batsch)
Lagena sulcata (Walker and Jacob)
Guttulina irregularis (D'Orbigny)
Guttulina irregularis, fistulose var.
Guttulina spicaeformis (Roemer)
Globulina gibba D'Orbigny
Globulina gibba, fistulose var.
Globulina gibba D'Orbigny var. *tuberculata* D'Orbigny
Globulina minuta (Roemer)
Globulina munsteri (Reuss)
Globulina rotundata (Bornemann)

Glandulina laevigata D'Orbigny
Sigmomorphina jacksonensis (Cushman)
Polymorphina advena Cushman
Ramulina sp.
Nonion advenum (Cushman)
Nonion inexcavatum (Cushman and Applin)
Nonion micrum Cole
Nonion planatum Cushman and Thomas
Nonionella cockfieldensis Cushman and Ellisor
Noniella jacksonensis Cushman
Noniella hantkeni (Cushman and Applin)
Noniella hantkeni var. *spissa* Cushman
Camerina sp.
Operculina mariannensis Vaughan
Bolivinella sp.
Virgulina dibollensis Cushman and Applin
Bolivina jacksonensis Cushman and Applin
Bolivina sp.
Reussella eocena (Cushman)
Angulogerina ocalana Cushman
Trifarina bradyi Cushman var. *advena* Cushman
Discorbis assulata Cushman
Discorbis globulo-spinosa Cushman
Discorbis hemisphaerica Cushman
Lamarckina ocalana Cushman
Gyroidina soldanii D'Orbigny var.
Eponides jacksonensis (Cushman and Applin)
Siphonina advena Cushman var. *eocenica* Cushman and Applin
Siphonina cf. *jacksonensis* Cushman and Applin
Pulvinulinella exigua (H. B. Brady)
Globigerina sp.
Anomalina sp.
Planulina cf. *byramensis* (Cushman)
Cibicides americanus (Cushman)
Cibicides lobatulus (Walker and Jacob)
Cibicides mississippiensis (Cushman)
Cibicides pseudoungerianus (Cushman)
Cibicides yazooensis Cushman
Gypsina globula (Reuss)

OSTRACODA

Cytherella sp.
Cytherelloidea montgomeryensis Howe
Bairdia sp.
Paracypris franquesi Howe and Chambers
Cytheridea caldwellensis Howe and Chambers
Cytheridea grigsbyi Howe and Chambers
Cytheridea montgomeryensis Howe and Chambers
Paracytheridea belhavenensis Howe and Chambers
Cytheropteron montgomeryensis Howe and Chambers
Eocytheropteron spurgeonae Howe and Chambers
Cythereis deusseni Howe and Chambers
Cythereis florienensis Howe and Chambers
Cythereis gibsonensis Howe and Chambers
Cythereis hysonensis Howe and Chambers
Cythereis israelskyi Howe and Pyeatt
Cythereis jacksonensis Howe and Pyeatt
Cythereis montgomeryensis Howe and Chambers
Cythereis yazooensis Howe and Chambers
Cytheretta alexanderi Howe and Chambers
Brachycythere watervalleyensis Howe and Chambers

CONCLUSION

Obviously, this fauna, aside from *Nonionella cockfieldensis*, is related both to that of the Moody's Branch marl and to that of the Ocala limestone. Thus, at the Claiborne type locality *Nonionella cockfieldensis* appears to be restricted to the basal Jackson. It has been my experience that elsewhere in the Gulf Coast *Nonionella cockfieldensis* is restricted in this fashion.

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